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JOHN W. ALVORD
PRESIDENT OF THE ASSOCIATION

PROCEEDINGS

OF THE

THIRTIETH ANNUAL CONVENTION

OF THE

AMERICAN WATER WORKS ASSOCIATION

HELD AT

NEW ORLEANS, LA., APRIL 26-30, 1910

PUBLISHED BY THE PUBLICATION COMMITTEE

109648
2 5 11

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COMPOSED AND PRINTED
BY THE WILLIAMS & WILKINS COMPANY
AT THE WAVERLY PRESS
BALTIMORE, MD.

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ELECTRICITY IN WATER WORKS PUMPING

CHARLES B. BURDICK

Electricity in the water works has now been used for more than fifteen years, and the electric pump has taken a permanent place among the steam driven machines.

Like all other machinery in water works or elsewhere, the electric pump has its limitations. There is no prospect that it will replace our high duty crank and fly-wheel steam driven engines, except under very exceptional circumstances. There are situations, however, and they are very numerous in water works pumping, where the electric pump is not only a great convenience but a profitable investment. It is the object of this paper to make memorandum of the situations and circumstances under which electric pumping is profitable; to point out its limitations and to briefly describe a few of its typical applications.

Those conversant with water works design realize that the best machine for any service—other things being equal—is that machine which can be operated and maintained at the least annual cost, including operating charges, repairs, ordinary depreciation, and a reasonable interest charge on the money invested. This is the axiom of station design, and pre-supposes that the machines in question are adequate to meet the requirements of the service, and that the comparison is made under the service conditions that prevail, rather than a maximum or artificial condition.

There is more than one way of accomplishing a desired result in almost any water works. Machinery of widely varying types is often more or less applicable, especially in the smaller installations, and in the supply of our large cities there is sufficient difference in the species of an individual type to warrant a very thorough study of the local conditions in the selection of a pump. As in any power or pumping device, the use of electricity is a question of service, cost of power, and investment charge. There is perhaps no machinery installation where reliability and certainty of operation is of more importance than in the water works, There is probably no machinery plant in which a shut down may bring such disastrous consequences, and as this fact is indelibly impressed on all water works men, it will not be enlarged upon here, further than to say that continuity of service is the prerequisite of a water works machine.

ELECTRIC CURRENT

The tendency during the last ten years has been rapidly toward the almost universal use of the alternating current. The cost of the alternating apparatus and the economy of its transmission has caused practically its universal adoption. As a water works power, it suffers a slight embarrassment owing to the necessarily fixed speed of the motors, and although it is practicable to modify the speed within certain limitations, the arrangements involved are somewhat intricate and costly and have not usually been adopted in water works practice.

The direct current still has a small field where the transmission distance is short, say 2000 or 3000 feet, and where a considerably graduated range of speed is needed.

The alternating current motors are usually operated under 200 to 400 volts, and where the current must be transmitted for some distance transformers are employed so that the voltage on the transmission line roughly approximates 1000 volts per mile of transmission. The large majority of installations use overhead wires, and although such lines are somewhat subject to atmospheric disturbances, relative costs and reliability usually warrants their use. It is proposed to use the conduit system on a four mile transmission in the new electrically driven water works at Niagara Falls. The question of overhead or underground wires was canvassed very thoroughly in connection with the new steel plant at Gary, involving the transmission of a large amount of power over maximum distances of about one mile, including an electric driven water works. In this plant the overhead system was adopted.

TYPES AND CHARACTERISTICS OF PUMPS

The electric pump is necessarily a combination of two devices, —the motor and the pump.

For reasonable economy the motor must run at a relatively high speed compared to the ordinary pump and to save embarrassment in speed reduction mechanism, some compromise has been necessary in motor and pump speeds, and the pumps best adapted to high rotative speeds have been most frequently used.

The reciprocating power pump, from the minimum power standpoint, in units of small and medium sizes stands first. To promote reasonable uniformity of load, a multiplication of plungers is desirable, and the triplex pump—either single or double acting,—is commonly used. It must necessarily operate at a comparatively slow revolution speed—generally 30 r. p. m. or less. The wide disparity between this speed and that of the motor makes a satisfactory coupling a matter of considerable difficulty. A belted connection is more reliable than is generally supposed, and has been sometimes used. It is however, extravagant of space, and gives some trouble. The link belt, permitting a close connection, is successfully used on small machines. Usually, however, the motors are set upon a common bed with the pump and geared to an intermediate shaft. This connection, especially in the larger machines, is noisy, and requires more attention and repairs than any other part of the pumping device. Necessarily the triplex pumps, driven by an A. C. motor, must operate at constant speed, and the device is therefore applicable only where water storage or other exceptional circumstances permit a uniform pumping rate.

Small installations have been made involving a blow-off and a by-pass returning to the suction. Such machines have been operated against direct pressure in this manner, but it is evidently not an economical arrangement if the variations in pumpage are considerable.

The triplex pump, ranging from small sizes to large, will show a mechanical efficiency of from 65 to 75 per cent. The mechanical efficiency of a good belt transmission is high—usually 95 to 97 per cent. The mechanical efficiency of spur gearing may be very low, but first-class gearing in good condition will probably show an efficiency of between 87 and 93 per cent.

There is upon the market a semi-direct displacement impeller pump that has been operated with success with water wheels, and has also been connected to the electric motor. This pump compares favorably in mechanical efficiency with the triplex, and its comparatively high speed—from 200 to 400 r.p.m.—makes it adaptable to direct motor connection under exceptional circumstances and permits a moderate speed reduction in the usual case where gearing is used. These pumps will operate efficiently aganist the usual water works heads. Like the triplex pump, however, they are particularly adapted to the higher heads involved in pumping to the distribution system.

THE CENTRIFUGAL PUMP

By far the larger number of installations involve the centrifugal pump. It is particularly adapted to the electric motor on account of its rotative speed, which may be almost anything desired up to 1500 r.p.m., and the continuity of the water flow, the absence of shocks and noise, and its economy of space, make it particularly adaptable to the electric motor. The centrifugal pump (formerly a low head machine) has, through the multiplication of runners and the use of diffusion vanes, become adapted to any head desired. The machine is particularly adapted, however, to the low heads, to which reciprocating pumps are not best adapted, for situations where double pumping is necessary, as in the supply of water from wells or the low lift supply of filtration plants. For lifts of 100 feet or less, the single runner is commonly used, multi-runner machines being commonly used upon the higher lifts; the runners being multiplied at the rate of one to each 60 or 80 feet of lift.

These machines direct connected to electric motors, are manufactured in either the horizontal or vertical type. The horizontal machine has been most widely used, and in the present state of the art is believed to be the best and most reliable pumping device of the two.

The vertical shaft machine is necessary in certain situations where the pump must be in or within reach of the water, and the motor at some distance above. This situation arises frequently in the supplies drawn from our rivers, where the variation is large between the low water and flood planes.

There are several installations where pump and motor are separated by 20 to 80 feet of shafting. The principal troubles in these installations has arisen from defective balancing in the supports and bearing of the shaft. Intermediate bearings must be supplied at intervals of from 8 to 10 feet, and they must be stiff and strong or the shaft and bearings will be quickly destroyed. In the horizontal machine the end thrust is usually counteracted by an apportionment of the areas subject to discharge pressure on the two sides of the enclosed impellers, supplemented by a rigid thrust bearing, generally of the marine type, to take up the minor tendency to thrust. In the vertical machines the thrust is sometimes carried in a similar manner, but where the distance between motor and pump is considerable, involving a long shaft, the wisdom of using the rigid marine thrust is, in the writer's opinion, questionable.

It is believed that the best practice for long shafts consists in a mechanical thrust bearing at all or a part of the intermediate bearings, to be used only before the pump comes up to speed; the shaft and runners then being carried upon a hydraulic step either at the top or the bottom of the shaft. Where the head is rigidly fixed, it is probably practicable to secure this balance in the pump, but there are no mechanical thrust bearings that will carry a poorly balanced pump and a long shaft.

About four years' experience in the operation of electrically driven vertical shaft deep well pumps in the vicinity of Chicago where the speed of revolution approximates 1500, and the space between motors and pumps is about 100 feet, a hydraulic step at the top of the shaft, supplemented by a mechanical thrust bearing, has proven best. In these pumps the water for the step bearing under pressure is secured from the city mains. The tendency of the thrust is all downward, and the weight of the runner and shaft rests upon the mechanical bearing only when the pump is idle. The bearing is so designed that a slight vertical play of less than $\frac{1}{2}$ inch is permissible.

The limit of the upward movement in the hydraulic step is governed by a port opening covered by the step piston, and the pressure in the step is thus automatically controlled. The amount of water wasted (which is slight) can be minimized by pinching down a cock in the water supply pipe of the bearing under any reasonably fixed condition of service.

In the vertical and also the horizontal installations the motor is attached to the pump shaft by a flexible coupling, and the tendency to thrust of the motor—which is a comparatively simple matter—is provided by a separate bearing.

CENTRIFUGAL PUMP EFFICIENCY

The mechanical efficiency of the centrifugal pump is particularly important in situations where it operates a large part of the time. In these situations the efficiency is perhaps more than ordinarily important, because low first cost makes the power charge the most important item in the bill of operation.

In common with most new devices, the centrifugal pump has suffered by claiming overmuch by its builders. The art of design has apparently not reached that stage where the pumps of all the prominent builders approach with certainty fixed standards of service and efficiency. It is not uncommon to find some misfits in the pumps of manufacturers wellknown and successful in the general pump business.

The information in regard to centrifugal pump design is largely in the hands of manufacturers, and is, of course, somewhat jealously guarded. It is therefore not surprising that we sometimes find pumps that do not fit the conditions of speed, delivery, and head for which they were intended, or which give their best efficiency at some point in the delivery curve other than that for which they were designed. It is not uncommon that reputable manufacturers produce an excellent efficiency under certain conditions, and fall down lamentably under slightly different circumstances, apparently as easy to meet. This probably arises in part from incorrect theory in the application of experiments on the smaller machines to larger sizes, and the pump buyer will do well, before purchasing, to make some inquiries into the efficiency results secured by the bidder under conditions closely approximating his own.

The rate of water delivery appears, under water works lifts, to be more important in the efficiency matter than any other one factor. Mr. William O. Weber, M. Am. Soc. M. E. (*Engineering News,* January 10, 1907) sets down the following as reasonable comparative efficiencies, running from small to large pumps:

TABLE SHOWING RELATION OF SIZE TO PUMP EFFICIENCY

SIZE OF PUMP	DELIVERY IN GALLONS	MECHANICAL EFFICIENCY
Inches	Per minute	Per cent
2	98	38
3	220	45
4	392	52
5	881	60
6	1,567	64
18	7,932	77
32	25,000	80

The second column is interpolated by the writer on the basis of a discharge velocity of 10 feet per second. In practice there is considerable variation in this velocity. Economical results can apparently be obtained at considerably higher figures. The writer has been interested to compare, from time to time, with these efficiencies the results that have come under his personal notice, and these figures are believed to represent approximately the results that may be secured at this time.

Considerable ingenuity has been shown in the manipulation of the pump curve characteristics. Where the delivery is variable a flat efficiency curve is desirable, and in nearly all installations it is important to so regulate the matter of delivery and head that in case of a sudden reduction in pressure the delivery does not so increase as to overload and burn out the motor or fuses.

In reliability of operation and cost of maintenance the centrifugal pump ranks with the best. In pumps operating constantly there have been some mysterious troubles from pitting, but these troubles are comparatively rare, and the small size and simplicity of the machine makes repairs and renewals cheap and easy.

PART LOAD EFFICIENCY

The accompanying diagram (Fig. 3) shows characteristic curves of an electrically driven centrifugal pump of about 5,000,000 gallons capacity per twenty-four hours. This dia-

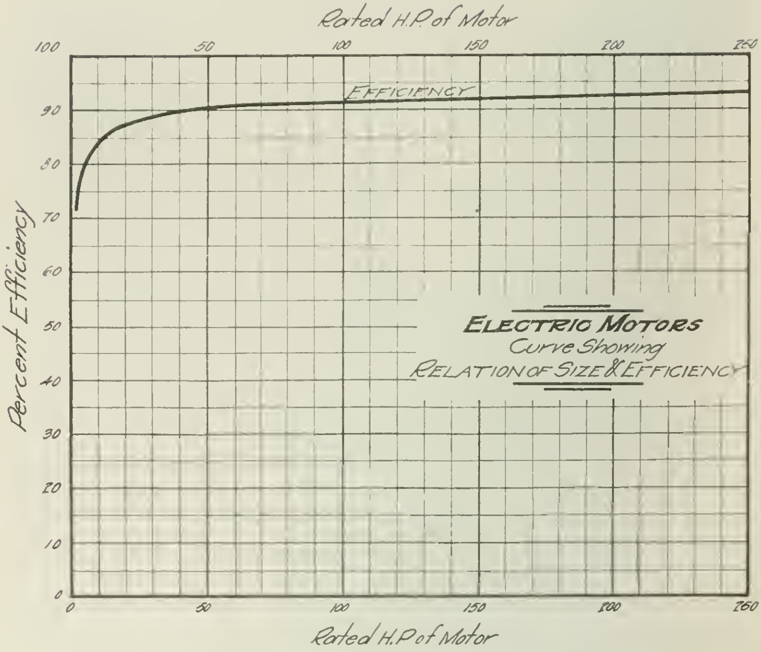

Rated H.P. of Motor
100
50
100
150
200
250
90
80
70
60
50
40
30
20
10
0
Percent Efficiency
EFFICIENCY
ELECTRIC MOTORS
Curve Showing
RELATION OF SIZE & EFFICIENCY
0
50
100
150
200
250
Rated H.P. of Motor

FIG. 1

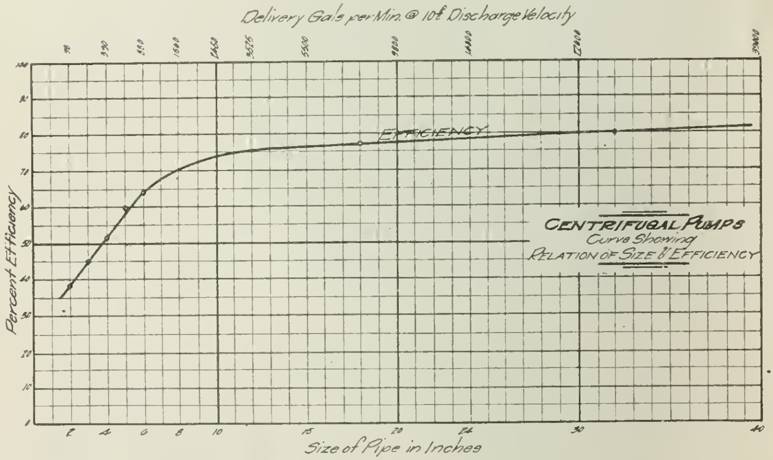

Delivery Gals per Min. @ 10 ft Discharge Velocity
98
390
880
1600
2450
3525
5500
9800
14100
22000
39000
100
90
80
70
60
50
40
30
20
10
0
Percent Efficiency
EFFICIENCY
CENTRIFUGAL PUMPS
Curve Showing
RELATION OF SIZE & EFFICIENCY
2
4
6
8
10
15
20
24
30
40
Size of Pipe in Inches

FIG. 2

gram is presented for the purpose of illustrating the relation of the part load to the full load efficiency. Four efficiency curves are shown—the pump curve, the motor curve, the over-all curve, and the curve of relation between full load and part load, considering the full load efficiency as 100 per cent, all under a fixed speed, which is required by the induction motor.

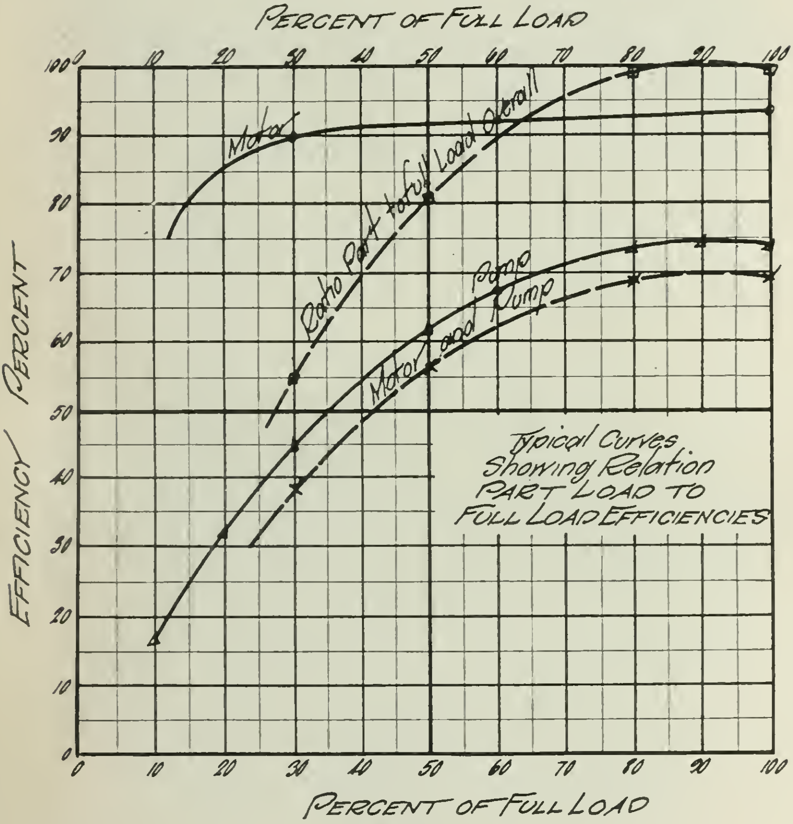
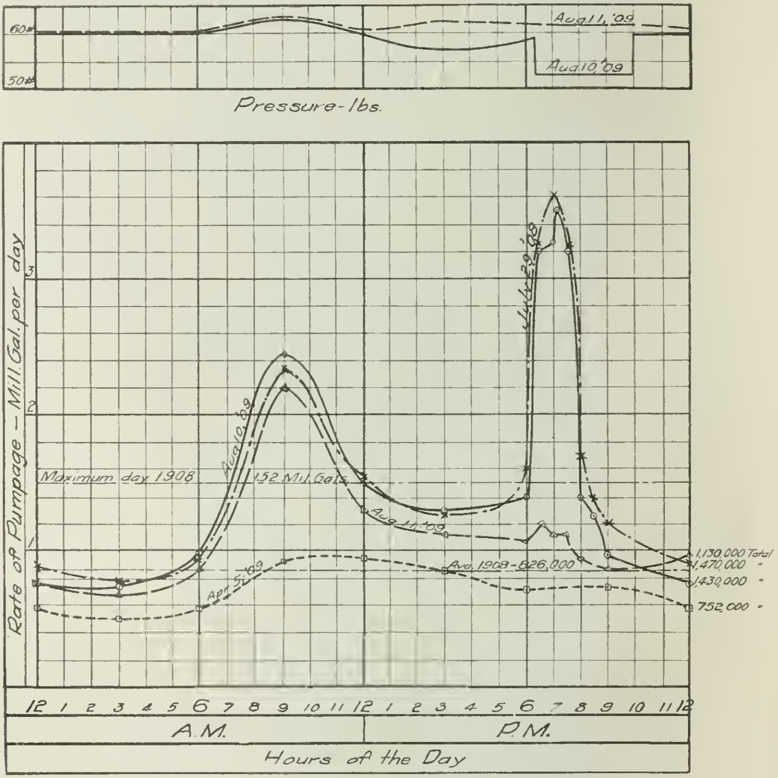


FIG. 3

Comparing with the full load efficiency (100 per cent), it will be observed that ¾ load approximates the same efficiency; ½ load 92 per cent, and ¼ load 50 per cent. Down to ½ load this is not a bad showing as compared to the reciprocating pumping engine. The reduced deliveries, however, involve some increase in pressure, and the importance is observable of operating the electric pump on a reservoir service, if practicable.

It has been observed that the tendency to meter has resulted in accentuating the variations in the station pumpage, for the reason that waste is usually a constant draught, and with the waste eliminated, the variations in legitimate use become emphasized.



Note:- Displacement 81.83 Gals per Rev R.P.M. x .117 = Mil. Gal. Rate.

FIG. 4

A striking instance of this is shown in the day rate pumpage curve at Manistee, Michigan, shown herewith, Fig. 4, in which upon a day of maximum pumpage (about 1,500,000 gallons), the pumpage rate runs all the way from 800,000 to 3,500,000 gallons, running at about the first named figure during the night hours, rising to about 2,000,000 gallons at 10 a.m., falling to about 1,250,000 gallons at noon, and rising to the maximum between 6 and 8 P.M.—sprinkling hours. The per capita consumption at Manistee is about 90 gallons.

A somewhat similar curve prevails at Winona, Minn. At this place the annual pumpage has been reduced about half in fifteen years, to a present per capita consumption of about 85 gallons, and although the average pumpage approximates 1,500,000 gallons, and the maximum day about 3,000,000, it is necessary during the late afternoon hours of a summer day to throw in a second pump to assist a 6,000,000 gallon crank and fly wheel machine.

The value of storage in these plants will be seen, and it is particularly valuable to the electric driven pump, for a penalty is frequently imposed on peak loads if electricity is purchased.

MAIN STATIONS

In the pumping of water electrically, power must go through a number of transformations to become effective, and the power losses are necessarily considerable. They will range from engine shaft to water delivery, as follows:

	Per Cent
Generators	90 to 93
Step up transformers (if necessary)	96 to 98
Transmission line	90 to 95
Step down transformers	96 to 98
Motors	88 to 93
Pumps	50 to 80
Total	33 to 63

If transformation of current is not necessary, these over-all efficiencies can be improved 6 to 10 per cent.

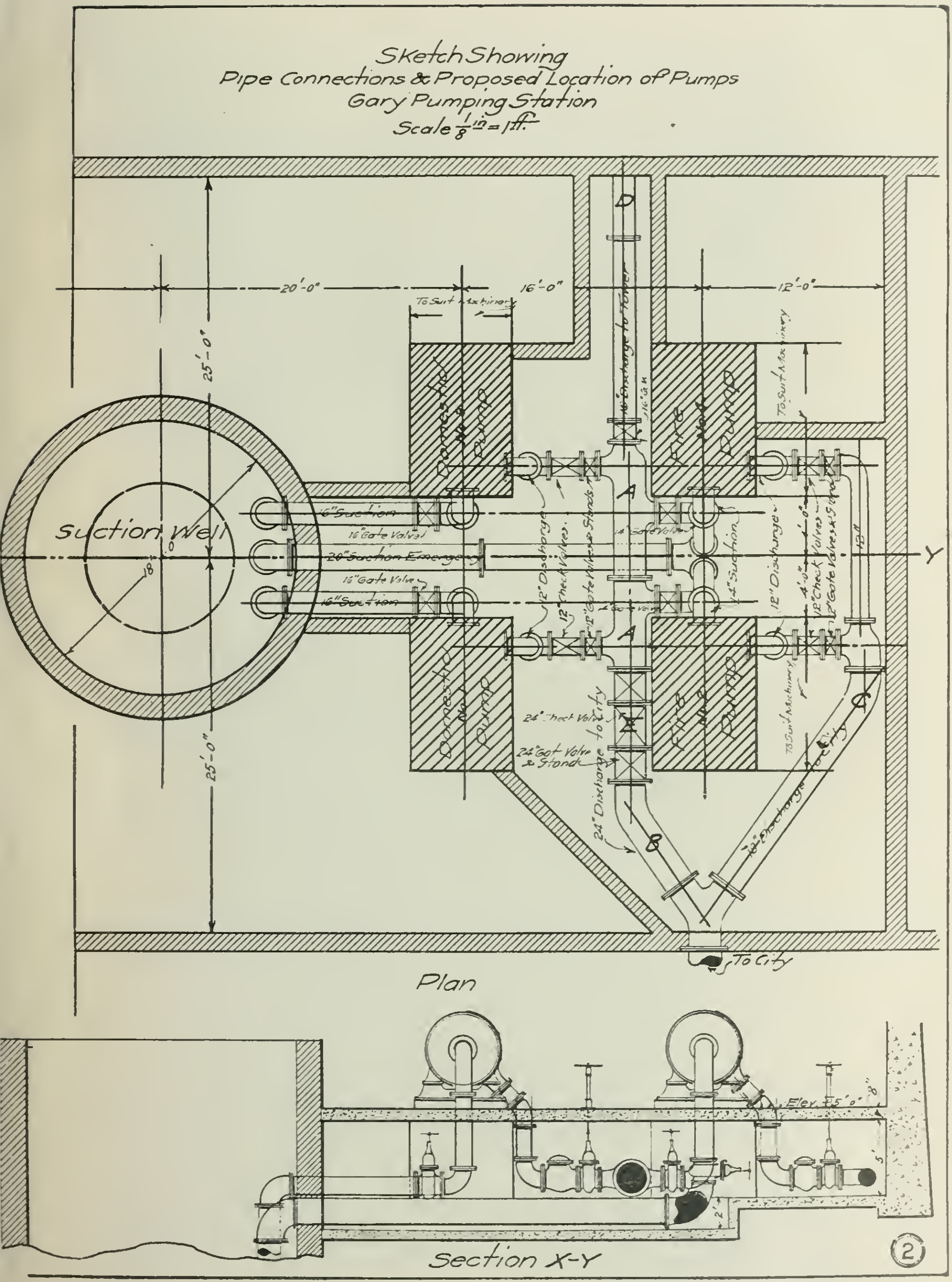
It will therefore be seen that in the use of electric current generated from steam some important circumstances must offset the power losses to make desirable the electric pump. Situations do exist, however, that warrant the use of electricity in main stations. A typical instance of this kind is presented in the water supply of the industrial town of Gary. The water works is owned and operated by a company closely related to the steel plant in which electricity in many thousand horse power is generated from blast furnace gases, with a large steam-driven electric station in reserve. With power from this large generating station available within one mile of the water works, it was deemed advisable to use electricity in the water supply of the city, which is ultimately expected to be a large water user; parts of the system being designed for 60 to 80 million gallons per day.

The present installation consists of four single stage centrifugal pumps, electric driven, each of 5,000,000 gallons capacity per twenty-four hours, arranged as shown on the accompanying plat (Fig. 5). The pumps are arranged in the form of a square, as shown. Nos. 1 and 3—the domestic pumps—operate against 75 pounds total lift, and are operated by 250 h.p. motors. Nos. 2 and 4 are fire pumps, operated by 150 h.p. motors, and are piped upon the "booster" plan; they being so arranged as to take suction under 75 pounds pressure and add 50 pounds thereto, delivering water to the mains under approximately 125 pounds.

An elevated water tank of 300,000 gallons capacity, sufficiently high to accommodate the 75 pounds pressure, is attached to the header between the domestic and fire pumps. This arrangement of pumps and pipes has proven very satisfactory in operation.

Under ordinary circumstances the domestic pumps only are operated, the water passing from pumps through header A-Fig. 5 to the city, and the surplus passing to the elevated tank. By this means the pumps always operate at rated capacity. The valves upon the fire pumps remain open, and a part of the water passes through these pumps to the city main in amount according to the path of least resistance. Upon an alarm of fire the switch governing the fire pump is closed. As pressure is induced in the force main, a check valve, marked *E* in the accompanying sketch, is seated, and thereafter all water passes through the fire pump or pumps, and is delivered under 125 pounds pressure.

In case it should be necessary to shut down one of the domestic pumps, the tank (which is never shut off the system) is available to supply water under 75 pounds pressure to the fire pumps.



Sketch Showing
Pipe Connections & Proposed Location of Pumps
Gary Pumping Station
Scale 1/8 in = 1 ft.
20'-0"
16'-0"
12'-0"
25'-0"
25'-0"
To Suit Machinery
To Suit Machinery
To Suit Machinery
D
16" Discharge to Tower
16" G.V.
Domestic No 1 Pump
Domestic No 2 Pump
Fire No 1 Pump
Fire No 2 Pump
Suction Well
18'
0
16" Suction
16" Gate Valves
20" Suction Emergency
16" Gate Valve
16" Suction
12" Discharge
12" Check Valves
12" Gate Valves & Stands
14" Gate Valves
14" Gate Valve
14" Suction
A
A
12" Discharge
4'-0"
4'-0"
12" Check Valves
12" Gate Valves & Stands
12"
Y
24" Check Valve
24" Gate Valve & Stand
24" Discharge to City
B
C
12" Discharge to City
To City
Plan
Elev. 5'-0"
8"
5'
2'
Section X-Y
②

FIG. 5

This arrangement is particularly satisfactory, in that it obviates the necessity of cutting off the elevated tank during fire, and it makes the water stored therein under pressure available in case of accident to the domestic pumps. To raise fire pressure no valves are operated. The closing of the fire pump switch alone is required. The fire pumps are also arranged with a suitable suction connection so that they may be used for the domestic supply of the city if needed.

In the new water works station under construction at Niagara Falls, N. Y. (present consumption about 14,000,000 gallons), electricity has been adopted in the new main station. The reason for its adoption lies in the unusually low price of electricity available from the large water power generating stations at that place. The present power contract is on the basis of $9.00 per horse power per year for twenty-four hour power measured at the generating station. This is said to be equivalent to about $13.00 at the switchboard of the pumping station.

The power is to be transmitted about four miles from each of two generating stations by the underground conduit system, under a voltage of 10,000, transformed to 400 at the motors. The "everyday contract" at the rate named above is with one company. The second conduit from another generating station is only for emergency use, and the emergency power is paid for at the rate of $20.00 per horse power per year at the generating station only when used, plus interest and depreciation on the investment necessary to supply the power.

In this station the arrangement of pumps and pipes is similar to that described at Gary, except that the pumps operate under direct pressure, and the fire pumps and domestic pumps are duplicates. Six machines are provided each of 6,000,000 gallons capacity against 75 pounds. The machines are so piped that any one of the six pumps may act as either a domestic or fire pump.

Near Chicago, the water power plant of the Sanitary District, which is required by law to furnish power to the municipalities within the districts at cost for municipal purposes, is making contracts on the basis of $15.00 per horse power per year for 12-hour power, and $26.40 per horse power per year for 24-hour power. The District, however, bases its charge upon the peak load, viz., the average current during the highest five minute interval during each month, not including, however, the current for fire service, which is furnished free. A number of Chicago suburban towns have contracted for current under these terms, have installed electric pumps, and are now operating with district current. These are small plants delivering less than 1,000,000 gallons per day, and the comparison between electricity and steam was made under the rather extravagant steam consumption conditions which prevail in most small plants.

A third set of conditions which warrant electrical pumping is illustrated in the water supplies of the North Shore Electric Company,—also near Chicago, This company supplies electricity to a belt of suburban towns surrounding the city, from Waukegan on the north to LaGrange on the west, and Harvey on the south of Chicago. Electricity is supplied from three modern steam power stations, located to the north, west and south of Chicago, and the power lines are all interconnecting. The company also operates water works at Oak Park, LaGrange and Harvey—towns of from 10,000 to 20,000 population. At all three places the water supply is derived from wells in the Potsdam sandstone formation, 1,200 to 1,800 feet deep, and involving lifts to the ground surface at the various places ranging from 50 to 200 feet. The deep wells are pumped by vertical shaft electric driven multistage centrifugal pumps, accommodated in well tubes 15 inches in diameter. The well units have a capacity of about 350 gallons per minute, and the pumps run at about 1200 r.p.m.

The electric high lift pumping facilities do not differ materially from the installations previously described. Power is distributed by overhead lines.

The justification for electric power consists in the unification of power generation for the several water works in a central power station of high economy, coupled with the fact that the stations have already a high electric light and power load, and although the transmission and conversion losses in operating the pumps are high, they are offset by the reduced labor costs in the water works stations and the necessarily high fuel costs in these isolated pumping stations of moderate capacity, should they be operated by steam. Even if so operated, it would probably be economical to drive the well pumps electrically.

SUB-STATIONS

In the rehabilitation of old plants, perhaps the most frequent use for electricity is found in the operation of sub-stations where it is necessary to develop new or additional supplies somewhat distant from the main pumping station. These are cases where a part of all of the city supply is pumped against a comparatively low head and delivered to the main station, In these situations electric power can profitably be generated in the main pumping station where boilers and labor are already available. This power can be developed at a moderate cost, inasmuch as the only important items of expense are the coal consumed and fixed charges on the investment. There is usually sufficient labor in a main station to generate the necessary current without additional employees.

It is practicable to make small sub-stations automatic in operation, the pumps being started and stopped from the main station several miles distant. At Adrian, Michigan, where a plant of this type was built to supply a new water to a filtration plant, the sub-station two miles distant has operated very satisfactorily for about twelve years. The transmission line carries telephone wire, and it is the custom to operate the sub-station with the telephone receiver hanging down. The engineer at the central station, upon throwing the switch, steps to the telephone and hears the machinery start and come up to speed. From time to time he steps to the phone during the period of operation, and soon learns to judge from the sound as to the satisfactory running of the machinery. A man visits the sub-station each day to fill oil cups, etc. Steam reserve is provided at this station for emergency, but for a number of years after this installation was completed it had not been used except to test it.

HIGH LEVEL STATIONS

In a number of cities, owing to considerable differences in ground elevation, it is economical to divide the pipe system into two districts. Usually the low pressure district is the larger. In these situations electricity can often be used to advantage, and in many systems where the topography is broken, small districts can be supplied at the desired pressure with a considerable saving in the lift to the main city distribution system by installing electrically driven pumps upon the border of the high level district.

The same plan has been suggested to relieve temporary deficiencies in the supplying capacity of the mains in some of our large cities. At Dubuque, Iowa, about a quarter of the water supply is delivered to a high level residence district by an electric pump, through power generated at the main water works station and transmitted about four miles. This pump takes its suction from a reservoir feeding the low level pipe system, and delivers its supply through the distribution system of the high level district to a standpipe. This station, in case of emergency can deliver its water under fire pressure to the mains of the low level district.

At Lemont, Illinois (a small village near Chicago), in which the water works is electrically operated and ordinarily delivers its water to a capacious reservoir upon high ground, an electrically driven fire pump is installed at the reservoir, which, in case of fire, draws its supply from the reservoir and raises the pressure in the village distribution system.

RESERVE MACHINERY

It is the general rule in water works that a duplicate machine be held in reserve in case of a break down in the fire service. This is a good rule. Its wisdom has been time and again proved.

Electric pumps and electric transmission lines are more certain and continuous in their operation than was generally supposed when the first installations were made, but no machine is sufficiently reliable to protect a city against fire without reserve, and it is particularly important that a city water supply shall not be at the mercy of an overhead transmission line. It is particularly liable to derangement during electric storms when water is often needed for fire service. The deficiencies in electrical apparatus and transmission lines can frequently be made good by sufficient water storage, but in the large majority of cases a reserve, using a different application of power, is advisable for emergency use, and this charge must, of course, be borne by the electrical installation and considered in comparisons of figures when the use of electricity is contemplated.

In plants of moderate size, employing electric substations, the gasoline or gas engine is a convenient and useful reserve machine. It consumes no fuel except when operated, and it can be easily and quickly started.

Steam reserve with a banked boiler is a constant expense, although small. At Adrian a steam pump is held in reserve in the sub-station for emergencies. At Dubuque a gasoline engine serves the same purpose, and the station service can be further supplemented by an old steam station ordinarily not used. At Gary no reserve machinery is as yet provided. The present pumpage is small, and the water storage is sufficient to tide over any short interruptions in the power. It is proposed to install a gas engine reserve when required.

OLD PLANTS

The question frequently arises as to the advisability of substituting purchased electricity for steam in the operation of established steam pumping plants in our cities of moderate size. The power bill in the water works station is high in proportion to the horse power output. The ambitious manager of the local electric plant, in the search for business, notes this fact, compares it with the cost of power in his station, and concludes that the municipality can profitably purchase electric current from him for the municipal water works.

There are few instances, however, in cities of moderate size where an established steam operated water works station can afford to pump electrically with current purchased from a steam driven electric station. In the first place, the electric company expects a profit on its product. Before applying this profit, it adds to the cost of manufacture, the cost of distribution and sale, which is a large item in the city electric plant. Furthermore the water works, while reducing its coal bill to the figure necessary to maintain a steam reserve, can only partially dispense with its station labor charge, and it must continue to pay fixed charges on the steam installation already made. If the demand for power were approximately constant, there would probably be still a chance for a local electric company, but the ordinary water works in a town of moderate size, unless large storage is available, requires power during fires at about four times the ordinary rate.

When all these factors are considered, although each case is a case by itself, it will usually be found that the local electric company cannot afford to furnish power at a price that is attractive to the municipal water works, except in the case of small villages.

DISCUSSION

Mr. J. Davis Barnett: I would like to ask Mr. Burdick whether in looking up information for this paper, he in any case met with especial trouble over and above that which pertains to using high voltage motors at all times, in using high voltage motors applied to centrifugal pumps? I ask the question because the total weight and therefore the cost of the plant drops very quickly as you make use of higher voltages. As the paper says, most all the plants I have seen on this continent use but from 200 to 400 volts, and yet the manufacturers in Germany, Switzerland, Sweden and Great Britain are very anxious to supply plants at a higher voltage.

Then I would like to ask him if he met any case of special trouble at a higher number of revolutions per minute? The percentage of actual efficiency goes up quickly if you are willing to accept pumps at high revolutions; and it seems to me that if you get your bearings and oiling apparatus efficient for 750 or 800 r.p.m. that that quality of workmanship ought to be efficient for 1500 r.p.m. I do not know whether that is so, or not; but if any one present knows of cases where it is not so I would like to hear from him. My experience seems to show that the American manufacturers are slow in their wish to change patterns or to forestall the limited American market for pumps; but I think they are going up to the very high voltages and the very high number of revolutions.

Mr. Chas. B. Burdick: I would answer the question of the last speaker by saying that I made no special review of the electrical pumping question before writing the paper, which represents particularly those installations with which I am more personally familiar. As far as my experience has gone we have confined ourselves to the lower voltages, and personally I have experienced no trouble whatever with the electrical apparatus; the only troubles that have come particularly to my notice have been pump troubles. The electrical apparatus throughout has proved very satisfactory. As the last speaker stated, I personally have little doubt that the tendency in the future will be to higher speeds of revolution. I am unable to predict what speeds of revolution will ultimately be reached, but the tendency has been to increase them. It is not uncommon now to find pumps exceeding 1000 r.p. m. that apparently are doing very satisfactory work.

Mr. Henry L. Lyon (*by letter*): The paper by Mr. Burdick deals with small electrically driven pumps, while those which I have in operation are large ones. I suppose, therefore, the desire to hear from me was a desire to know the results from the operation of our pumps rather than to learn details of construction.

In Buffalo we were short of capacity to meet our needs, and our station was not large enough to erect another steam driven pump. We needed a pump, and needed it at once. The pump works contracted to erect a 25-million gallon vertical electrically driven centrifugal pump in a short time for $30,490. The price was attractive, as a steam pump of the same capacity with necessary boilers would probably have cost about $125,000. The pump was erected with a 1500 hp. motor and it first used about 1400 hp. and pumped over 25-million gallons of water. We received Niagara Falls power at an agreed price of $25.00 per hp. year for a 1500 hp. motor. The pump was very satisfactory for a few months and we contracted for a second one. We needed the 50-million gallon capacity and the cost of operation was almost exactly what we were paying for steam power taking investment value into consideration. As it was necessary to shut down for cleaning purposes and for repairs, and we were paying for power whether used or not, we contracted for a third pump, so that we could keep two in operation continuously.

After about six months, the first pump showed a falling off in capacity, but we could not spare it from service for a year. The pump had then showed a falling off of about 20 per cent. We took it apart and found the impellers badly pitted, some of the blades being worn nearly half off. We believe it was on account of the rapid revolutions in the water (500 per minute). New impellers were put in and it became as good as new. I think the impellers cost about $2500.

We have gone through the same experience again, and are just now trying to get an opportunity to repair the impellers.

It has been operated most of the time under a 200 ft. head, part of the time under a 140 ft. head. A month ago we had shut it down to clean. It would not take suction when we tried to start it. We turned the discharge into the 140 ft head and it started. We then turned the discharge into the 200 ft. head and it carried it.

The second pump was supposed to be an exact duplicate of the first, but it would not pump more then 24-million gallons. After being in use for a year, new impellers exactly like the others were placed in it, and it pumped over 25-million gallons.

The third pump was by a different builder and varied somewhat in size, shape, and suction lift. When first put into operation, it used 2000 hp. and pumped 30-million gallons. The builders reconstructed the impellers and the diffusion veins and reduced the hp. to 1800 and the pumpage to 28-million. They again took out the impellers, cut off about three inches from the end of the impeller blades and reduced the hp. to 1650 and the pumpage to 26-million, and we accepted the pump.

As the suction enters the pump at the top, it requires a suction lift of 14 to 18 feet. We have a variation of three to four feet in the depth of the water in our wells and find that the less the suction lift the smoother the pump runs and the more water it will pump.

MAIN WATER WORKS PUMPING STATION

BRIEF REVIEW OF SOME RECENT PUBLIC IMPROVEMENTS IN NEW ORLEANS

BY GEORGE G. EARL

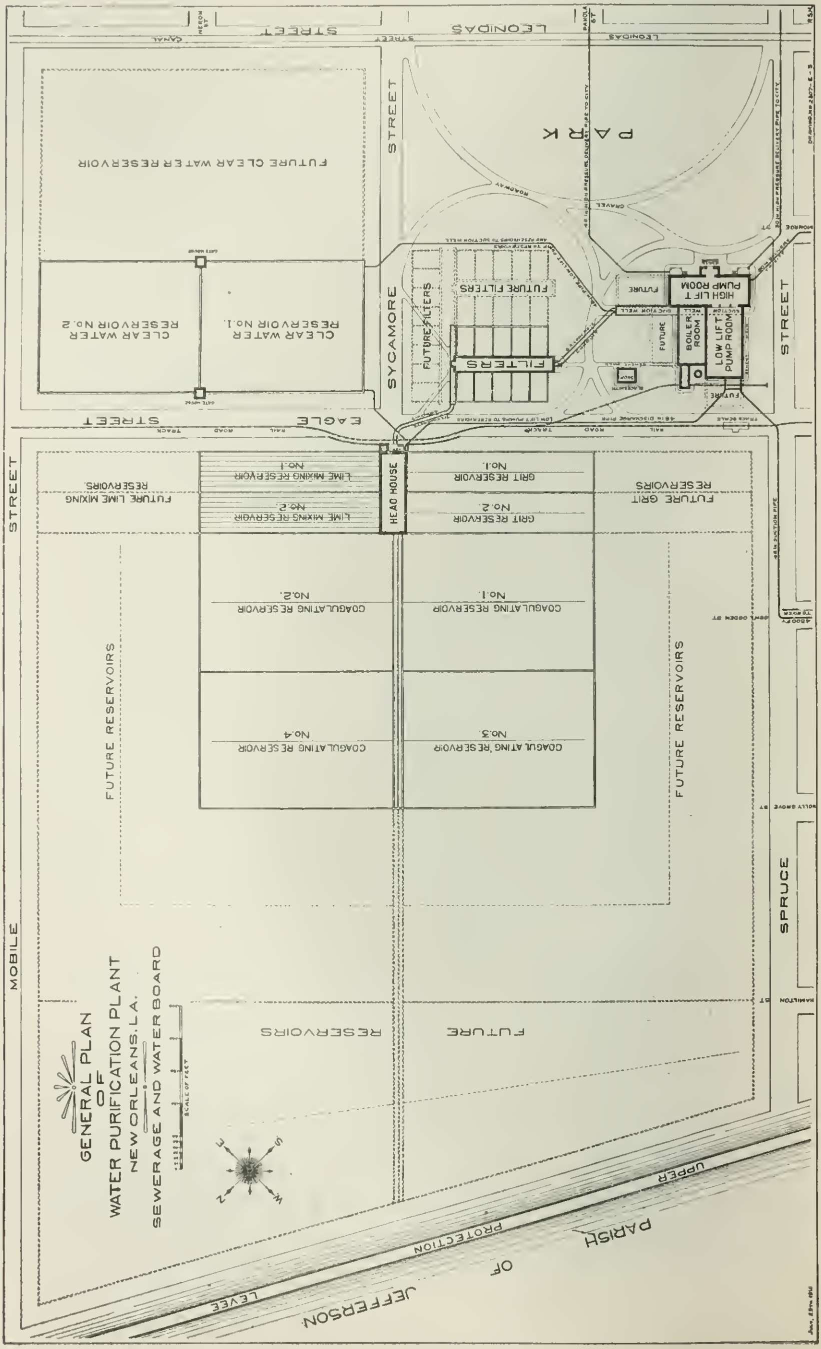
Ladies and Gentlemen, Members and Guests of the American Water Works Association:

You have already been welcomed to New Orleans by Mayor Behrman, who voices the sentiment of the city in this as in most other matters. It gives me great pleasure to join in that welcome and to assure you that we are going to do all we can to make your stay pleasant, and to convince you that you did wisely in choosing New Orleans as the "logical point" for your 1910 convention; incidentally, we want to convince you also that it is "the logical point" for the location of a World's Fair to celebrate the completion of the greatest work of our era, the opening of the Panama Canal in 1915; and we are going to count upon your assistance in these and other little ambitions that possess us.

Last year in requesting your consideration of New Orleans for your convention this year, I set forth something of her progress and advantages. To-night I am given an opportunity to go into these matters more fully; and it will be the fault of my presentation, and not the facts at my command, if you do not appreciate the praiseworthy effort and the vast progress which the city is now making.

The discouraging part of my talk is that the field I shall try to cover is too large to cover in an interesting manner in so short a time as can reasonably be given by you to hearing it.

It is probably safe to start by saying that no large city in the United States in the year 1895 had as far to go to really be a city as New Orleans and during the decade and a half from that date until now no city has made greater strides in all directions than this same New Orleans, which now has real foundation upon which to rear the structure of municipal greatness to which she aspires.



GENERAL PLAN OF WATER PURIFICATION PLANT

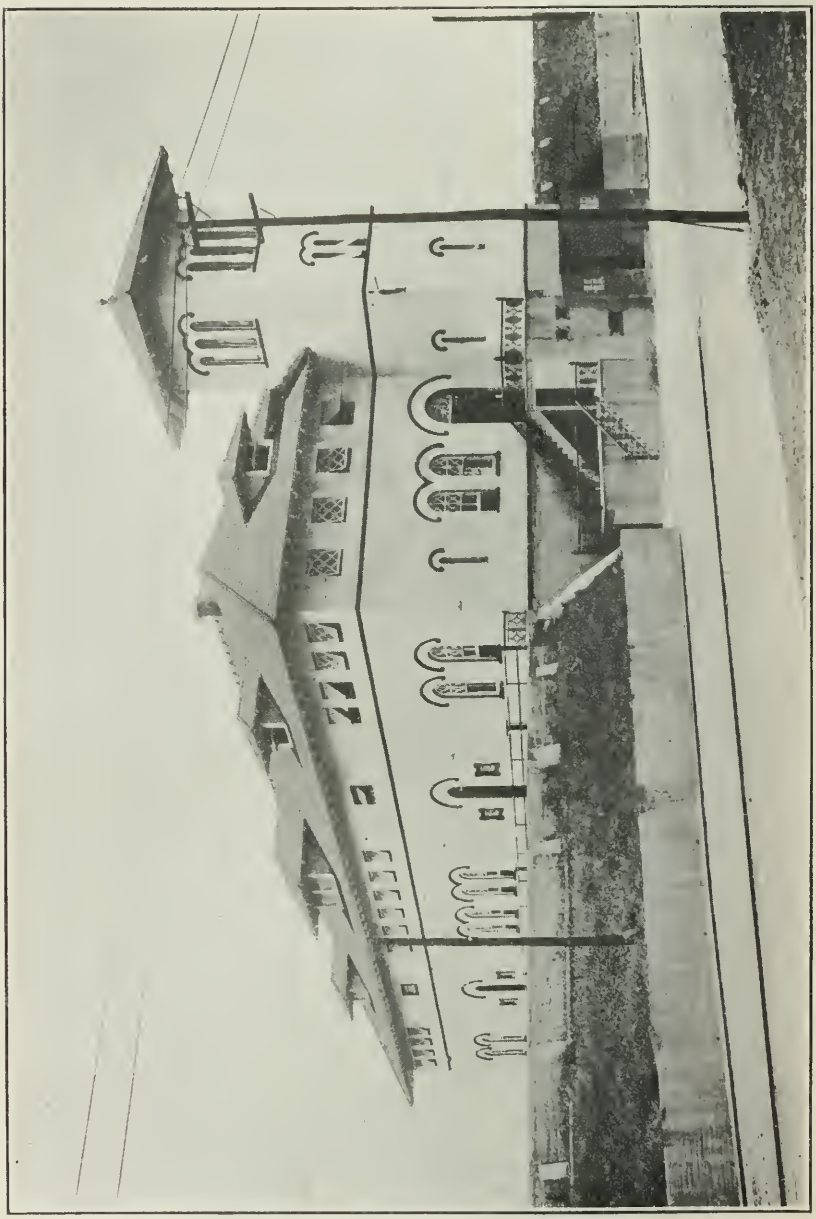
"The gods helps those who help themselves," it is said—we hope this is true. Through the long years when New Orleans was doing nothing effective to help herself she at least found that the "gods" do very little to help those who do not help themselves, and finally concluded to try the effect of self-help, with receptive attitude toward coöperation from both "gods" and men, which is desired but no longer greatly depended upon, except as earned through honorable efforts in good works.

It may be new to you, but it is a fact that in 1840, New Orleans was the third city in the United States in population, and that from 1800 to 1840, she stood never lower than the fifth, with only New York, Philadelphia, Baltimore and Boston ahead of her. This was due to the logic of her location when waterways compelled commerce and despite constantly recurring invasions of cholera and yellow fever, which, joined with general unsanitary conditions, brought death rates ranging from 40 to 81 per 1000 of population.

After 1840, the logic of natural location gave way to the more inexorable logic of death, and the growth of New Orleans as compared with rival cities showed favorably only in the cemeteries. In the later era, when railroads instead of waterways controlled commerce, the railroads sought those ports which best suited their own development, and the natural advantage of New Orleans as the outlet of the great Mississippi river valley was not potent to overcome the sanitary and other evils which surrounded and possessed her.

From 1840 to 1860 the annual death rate of New Orleans ranged from 37 to 110 per 1000. The war brought an embargo on commerce and a general cleaning up, which reduced the death rate for the decade 1860 to 1870 to below 40 per 1000, despite a terrible yellow fever epidemic which followed the renewal of commerce in 1867. In 1873 and again in 1878 frightful yellow fever epidemics were experienced; but the average death rate for the decade 1870 to 1880 was down to 32 per 1000.

After 1878 the State Health Board was reorganized and maritime commerce was facilitated, but under such vigorous and successful quarantine regulations that from this time yellow fever was kept out of the city, and ceased to be a factor in the death rate, and an absolute immunity for nearly twenty years encouraged the local belief that it was a thing of the past.



HEAD HOUSE

The general death rate, however, still remained high, 28.5 for the decade 1880 to 1890, and 27 for the decade 1890 to 1900, and the evil sanitary reputation of the city still remained.

Her drainage system was inadequate for even the reasonbly prompt removal of storm water. She had no sewerage system, and her vaults and cesspools and open street gutters were obnoxious to every sense. She had practically no water supply, her citizens depending almost exclusively upon rain water caught from their roofs and stored in wooden cisterns built above ground. She had a water works system covering one hundred and twenty five miles, or less than one-third of her inhabited streets, and serving less than 10 per cent of the premises of the city with the very muddy water of the Mississippi river at inadequate pressure and very high rates.

Her streets were mostly unpaved, or very badly paved.

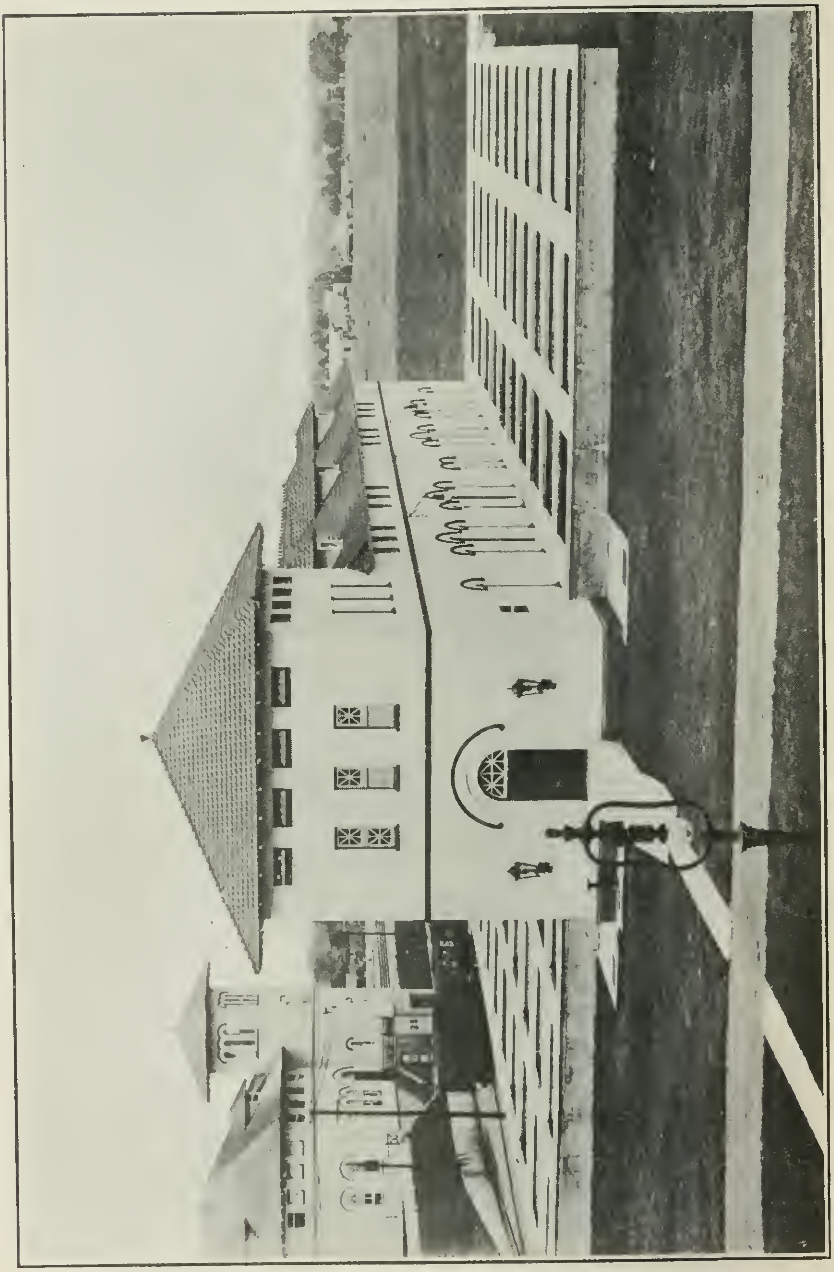
The wharves of the city were of the poorest and in the hands of lessees only interested in their own profit.

The schools and public buildings were anything but a credit to the community.

The railroad depots, hotels, even private buildings for business or residence purposes reflected the same general conditions.

By 1900 the city had gradually lost ground until she stood the thirteenth in population, with a rate of growth of less than 19 per cent in the last decade, an average death rate of twenty-seven per 1000, and an average rate of increase in assessed valuation of less than one per cent per annum.

In the early nineties the city commenced to wake up. Electric street cars were the first sign; then some street paving and a sewer franchise let to a private company, which failed; then a determined effort to improve the drainage of the city, resulting in the first survey and contour map, which really made it possible to intelligently study the best methods of dealing with local conditions. Then followed an expenditure of nearly $5,000,000 on a drainage system, commenced in 1897 and which went into operation in 1900, and made the first big improvement in conditions, reflected by an immediate and sustained reduction of 20 per cent in the death rate. Then the determination to build sewers and a water works system as municipal propositions, because yellow fever broke through the quarantine in 1897, and while the effect on the death rate was negligible, its



FILTERS

effect upon commerce and reputation were inestimably bad, and in the absence of specific knowledge of transmission of the disease it was believed that the construction of sewerage and water systems would enable the city to prevent it from getting a foothold.

Then the creation of a public wharf commission and of a public railroad commission, and the financing of all these, together with arrangements to make vast improvements in street paving and in public levees, as well as in many other directions.

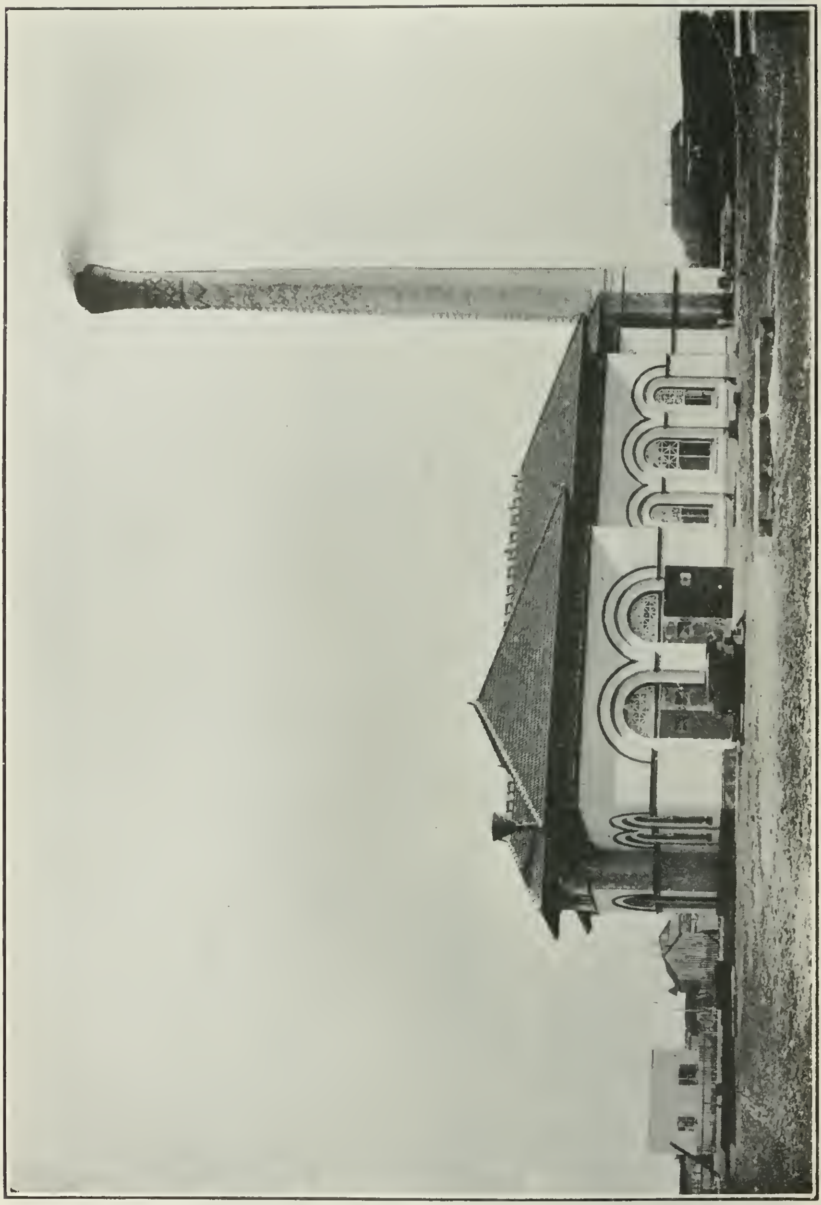
These public improvements, successfully completed or in progress, have encouraged private improvements, and they are bringing recognition from the world that New Orleans is effectively putting "her house in order" and can be relied upon to maintain her position and advance her own destiny as far and as fast as her resources and conditions will permit.

We are by no means at the end of the era of rapid improvements. The following figures show approximately the amounts expended since 1897 in different branches of public improvements and also about what will be expended during the next five years if the reasonable anticipations of different departments of the City Government are consummated.

EXPENDITURES

	1897 TO 1909 INCLUSIVE	1910 TO 1915 INCLUSIVE
Sewerage, water and main drainage system,	$19,000,000	$ 8,500,000
Street improvements, including local subsurface drainage,	4,500,000	10,000,000
Public buildings, City Hall, Court House, Schools, etc.,	2,500,000	1,500,000
Levee improvements,	6,000,000	4,000,000
Wharves and docks,	2,500,000	2,250,000
Public Belt Railroad,	500,000	1,500,000
Total,	$35,000,000	$27,750,000

The beneficial results of these improvements to date are everywhere visible; the average death rate since 1900 has fallen from 27 to about 19 per 1000, standing now about 16 per 1000 for the white and 25 per 1000 for the colored population. The assessed valuation of the city which was only increasing at a rate of one per cent up to 1900, has shown an average increase of better than



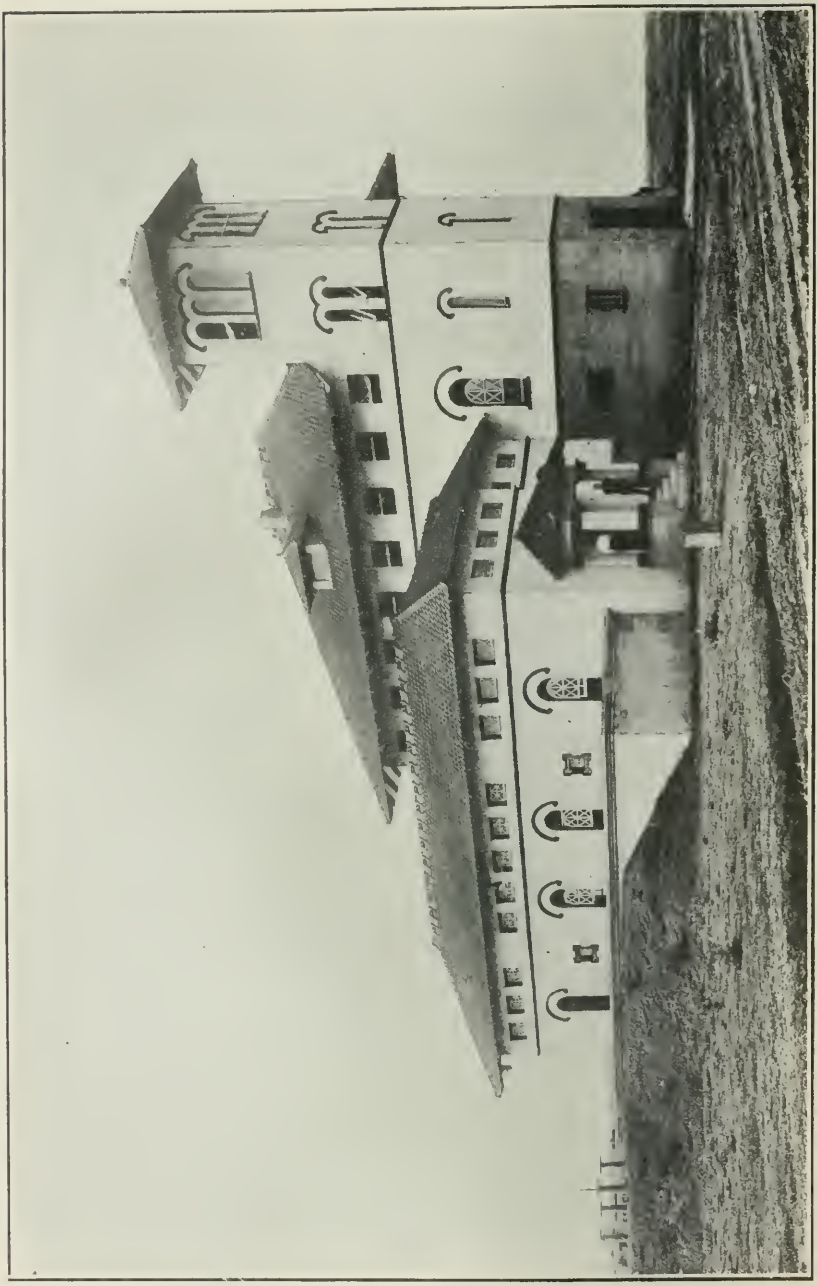
ALGIERS SEWERAGE AND WATER WORKS PUMPING STATION five per cent per annum since that date. The growth in population which was 18.7 per cent 1890 to 1900 wlll probably show something better at the present census.

In water works construction, 505 miles of water mains, with 4900 fire hydrants and two effective water purification stations of an aggregate capacity of 66,000,000 gallons per day, were completed and put into operation in three and one-half years from the letting of the first contract, and now, fourteen months after operation started, with practically no consumers, we have 18000 premises connected, 75 per cent of which are metered.

In sewerage construction, 328 miles of sewers, with nine pumping stations, have been built and put into operation since 1903.

The effect of these in pumping out the ground water which finds its way through the porous cement joints to the extent of 12,000,000 gallons per day is more than worth their cost, aside from their usefulness in carrying away the fouled household wastes through house connections which are gradually being made to them.

The main drainage system, comprising now sixty-three miles of main drains, of which as yet only seventeen miles are masonry lined, and seven electrically driven pumping stations, operated from a single electrical power station, has given an opportunity to construct new street improvements without the old time open gutter of justly unsavory reputation. About one hundred miles of sub-surface drainage pipe have already been connected with the main drainage system, and the prompt removal of the water from storms has resulted in the development of thousands of acres of low areas heretofore not capable of development at all, and in an improvement in conditions even in the higher and more thickly built sections of the city that is most conspicuous. We have still much to do in drainage extensions. We have some phenomenal rains in New Orleans; for a few moments it comes down on us at rates as high as seven inches in an hour. Two inches in one single hour is quite common, and sometimes nearly three inches. Seven inches in five hours and nine inches in twelve hours are records that we have had each once since 1900. It requires larger capacity canals, power and pumps to remove the water upon such occasions; we can now push a column of water out of the city ten feet square and half a mile long every minute,



ALGIERS HEAD HOUSE AND FILTERS

and we expect to add pumps and power shortly that will double that rate of removal.

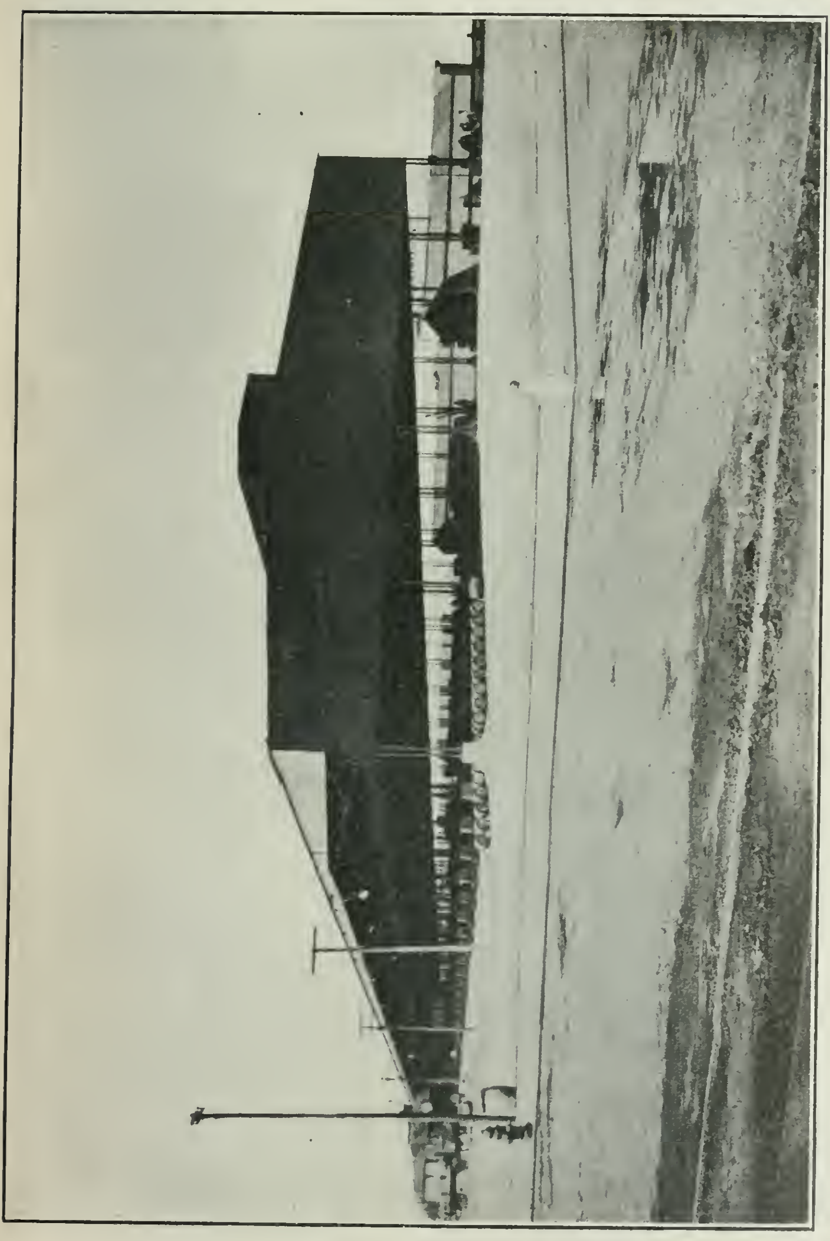
I am not so well in touch with and have not time to review the status and extent and effect of other municipal improvements herein briefly alluded to.

There has been nothing brilliant and nothing artificial in any portion of the recent progress of the city. Many citizens on many public boards have served the interest of the city without pay and with honesty and ability, often in the face of criticism and abuse, for the "old guard" who are said to have held a Boston tea party with the first cargo of ice which came to New Orleans and have in turn opposed gas and electric lights and electric street cars, and telephones, and health regulations, and levees and modern paving and municipal ownership of anything, and everything else in general, are still undaunted and looking for battle. They were certain that the drainage system would drain only the city treasury, just as former drainage works had so successfully drained it. They were confident that with the introduction of a sewerage system the city would become a pest hole, but consoled themselves with the heartening assurance that the thing simply could not be built. They knew that the new water pipe would not hold the pressure, and that the waters of the Mississippi river could not be purified and through the long construction period when these works were in progress and before they were ready to go into operation, they had ample opportunity to complain of the inconvenience of torn up streets and of the awful waste of money and the utter futility of it all.

The Sewerage and Water Board had not only these to contend with but it had also its friends who looked for results in completed work within less than half of the time essential to their accomplishment and who differed materially with each other, and from time to time with themselves, as to what ought to be done first. It had also difficulties of law and of finances to meet, but through it all it adhered steadily to a carefully devised plan of action announced so soon as such a plan could be formed.

In 1905 there was another invasion of yellow fever, with a start in July that would have resulted in a serious epidemic in the fall in former years, but the knowledge then just become general of the way to combat its spread through fighting the stegomyia mosquito, by which alone the disease is spread, and

MAIN SEWERAGE STATION "A"



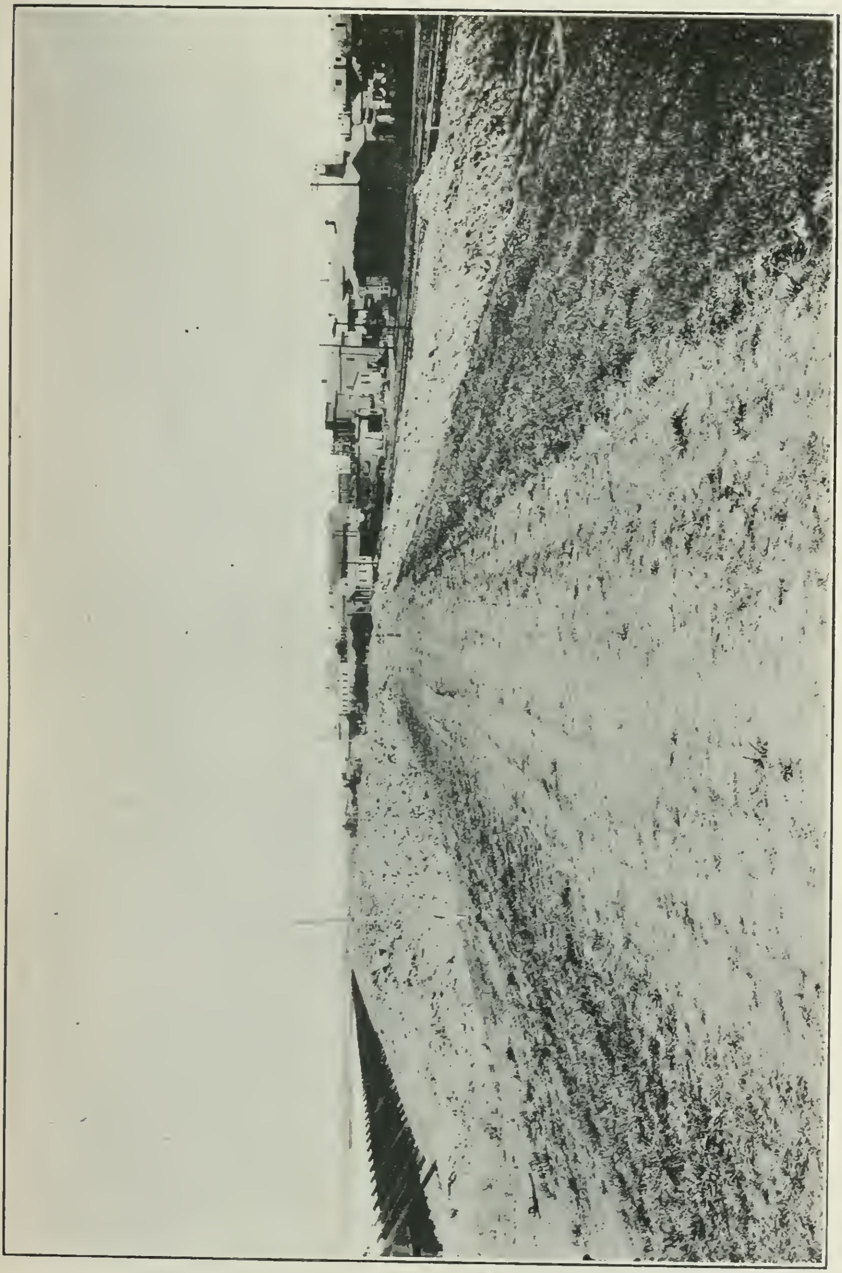
STEEL SHED ON RIVER FRONT

effective work in this direction eliminated the disease in a short period, and for all time removed further danger of yellow fever epidemics as a retarding factor in the development of southern cities. The stegomyia mosquito is a household pest breeding almost exclusively in cisterns or other containers of rain waters, and it therefore proved that the elimination of the old time cistern by the construction and universal use of a modern water works system was the most important step in making the spread of yellow fever impossible.

The thorough screening of existing cisterns was the method successfully applied in 1905, and this screening is still enforced wherever cisterns are maintained, but the law now contemplates the total abolition of cisterns at an early date.

It has been my purpose to-night to put you in touch with the local conditions and broad field of municipal improvements lately undertaken in New Orleans rather than to attempt anything of a technical description of any of the improvements themselves. This is an unusual thing in addressing a technical society, but it has seemed to me that the conditions surrounding this old city and the general treatment of its problems would be of more real interest to those who have come so far to attend this convention than any technical discussion.

Note: A lecture illustrated with lantern slides. A few of the many views shown are reproduced here.



NEW LEVEE ON RIVER

LEGAL DECISIONS CONCERNING THE SETTING OF METERS AND METER RATES AT ANNISTON, ALABAMA

H. B. RUDISILL

The Water works at Anniston are owned and operated by the Anniston Water Supply Company, a corporation. A contract for twenty years was made between the city of Anniston and T. G. Bush, and associates, beginning July 1, 1889, afterwards transferred to the Anniston Water Supply Company.

The plant consisting of the pumping station located at Coldwater Springs, which has a daily flow of twenty-two million gallons of water, eight and one-half miles from the city, where there are two Gaskill horizontal duplex compound condensing pumping engines, having a daily capacity of three million gallons each, four 80-h.p. return tubular boilers; a reservoir with a capacity of seven million gallons located six miles from the Spring at an elevation of nine hundred and eighty-five feet above sea level, three hundred and sixty-five feet above the Spring and two hundred and twenty-five feet above the city; and about twenty miles of cast iron mains from four inches to twenty inches diameter, on which was located one hundred fire hydrants, was operated for about ten years under the fixture rate system, with one engineer and one fireman running twelve hours per day and pumping one and one-half million gallons of water, the population being about 10,000.

A sewerage system having been constructed, a number of water closets were installed which were beginning to need repairs, lawn sprinklers in some instances were allowed to run night and day without the knowledge of the Water Company, and a general extravagant use and waste of water was indulged in, until the consumption of water reached such enormous proportions that it became necessary to put on a double crew of men at the pumping station and run the pumps twenty-four hours per day, pumping three million gallons daily, in order to keep up the supply. Under these conditions the use of meters seemed advisable and after making tests it was found that consumers who were paying from $4 to $6 per quarter were using and wasting by meter measure, from $20 to $30 per quarter, the adoption of the meter system was recommended.

The city authorities denied the right of the water company to change to meter measure on the ground that the contract provided fixed rates. After consulting our attorney and citing a decision by the St. Louis Court of Appeals, October term 1891, in the case of G. D. and H. B. McDanil, appellant vs. Springfield Water Company, respondent, appealed from Green County Circuit Court at Springfield, Mo., also the decision of the Supreme Court of Ala., in the case of Jennie M. Cary vs. the Capital City Water Company of Montgomery, Ala., both of which had similar contracts to that of the Anniston Water Supply Company. The decisions in both the lower and higher Courts being, in substance, that while the rates for the use of water were fixed by the contract, no provision was made for the waste of water and that the company had a perfect right to charge additional for water used or wasted in excessof a reasonable quantity. The company was then advised by its attorney that it had a right to install meters and charge for all water used in excess of a reasonable quantity. It then undertook to install meters in boxes on the sidewalk opposite premises supplied by it in defiance of the ruling of the city council. After installing about two hundred and fifty meters the idea occurred to the mayor to have an ordinance passed prohibiting the excavating of sidewalks by the company for the purpose of setting meters, and when this was done the company was obliged temporarily to discontinue setting meters and legal proceedings were instituted to compel the city to repeal this ordinance on the ground that it was unreasonable. The two hundred and fifty consumers who had been using water by meter measure were notified by the company that it would return to the fixture rate system until the legal point could be settled in the courts. This raised such a row with these two hundred and fifty consumers, who were saving money by the use of meters, that they then took up the matter with the city council and insisted so strongly that the contract be so modified as to put all consumers on a meter rate basis, that the mayor and council proposed a meter rate to the company which was accepted and the modification of the contract went into effect January 1, 1906, with the following results: At the present time, when all the services are now supplied through meters with an increase of 25 per cent in the number of consumers, there are three men at the pumping station running twelve hours per day six days per week pumping 1,500,000 gallons and using five tons of coal against five men at the pumping station running twenty-four hours per day, six days per week pumping 3,000,000 gallons and using eight tons of coal per day under the fixture rate system. The revenue of the company was temporarily reduced, but it is now greater than it has ever been. The company is highly pleased with the results of the meter system as well as the citizens, as will be shown by the extracts from the reports of superintendent of the water works and the mayor of Anniston:

From July 1, 1889, to January 1, 1906, water was furnished to the consumers at fixture rate. The daily consumption of water was two and one-half million gallons; there were at the pumping station, two engineers, two firemen and a helper, running twenty-four hours per day, six days in the week. The coal consumption was eight tons per day. After installing the meters, there are now employed at the pumping station three men, running twelve hours per day, six days in the week, the coal consumption is five tons per day, the pumpage one and one-half million gallons. The gravity pressure on the city mains increased 10 pound and 25 per cent more consumers are now using water than we had under the fixture rate system. The revenue of the company has not been reduced and it is, as you have seen, saving money, the consumers are saving money, are satisfied and would not go back to the fixture rate system under any circumstances. "All things considered, the furnishing of water by meter measure is the only equitable way."

[Signed] H. B. Rudisill,
Superintendent.

The council taking office in 1905, was, at the outset, confronted with a question that had vexed their predecessors for years—the water meter question. The Anniston Water Supply Company has been urgent in its insistence upon the right to measure water to consumers by meter. After thorough investigation and much negotiation, an agreement was reached by which the old flat rate system was abandoned and the meter system adopted. The result is tnat millions of gallons of water, theretofore wasted, has been saved, while the consumers of water have seen their water bills reduced from 25 to 50 per cent.

[Signed] Thos. E. Kilby, *Mayor.*

From this you will see that water companies have not only the right to limit the use of water to a reasonable quantity (although a contract fixing the rates has been made) but it is by far better for the company as well as the consumers to use water by meter measure.

CARE AND MAINTENANCE OF METERS IN SERVICE

By A. W. Cuddeback

The general meter question has been before the water works public for some time. The phase of this question that has been most dwelt upon, and which has been continually before us, has been the one of selling water by meter measurement as against the flat rate system, with its accompanying problems of effect on consumption and revenue. I think the time has now come to give the meter subject some thought and attention from a different point of view, and this is the proper handling of meters in service, and the selection of the size and type of meter for any given service.

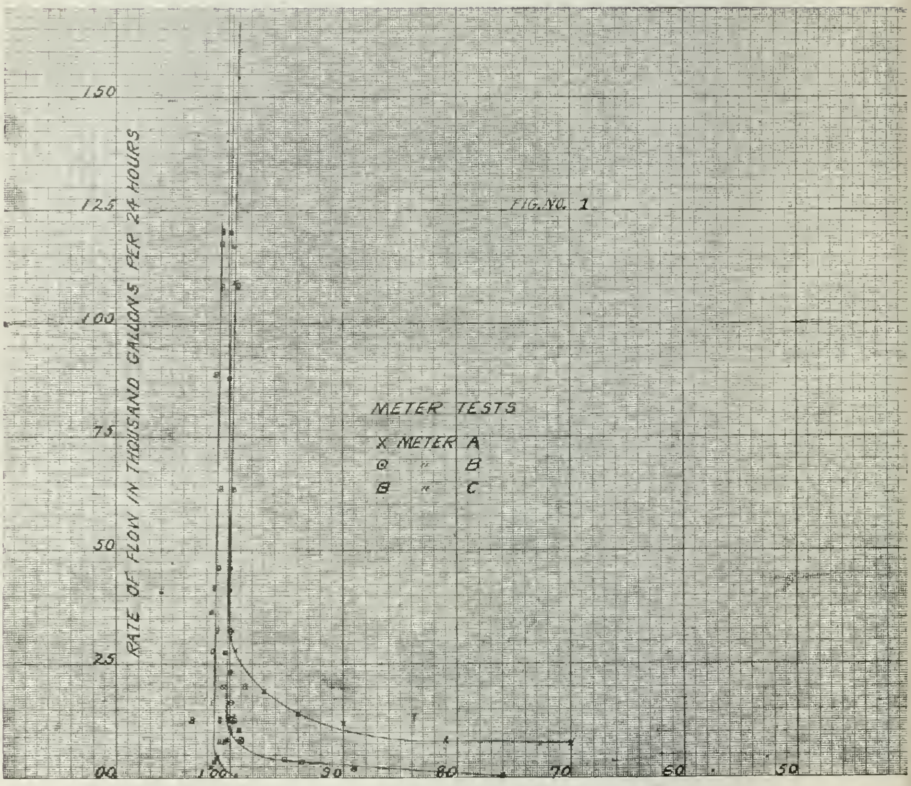
The meter as a tool or instrument for measuring water, like all other tools that we use in handling our business, needs constant attention, or it will not do the work that it is intended to do, i.e., measure with a reasonable degree of accuracy, the amount of water passing into a given property. When we are going to do a piece of work, we carefully select the tools appropriate to the class or kind of work that we are going to do. In providing for the measurement of water in a water works of any considerable size, we have a great many conditions to meet, and it is important that the proper kind of tool be selected to do the work efficiently and economically, and the question of the right kind of meter to apply to each particular service or class of services needs careful consideration.

It is necessary first of all, that the control of the meter should be absolutely in the hands of the water department. To this end it is, in my opinion, unadvisable to have privately owned meters. The water department should own and in this way control all meters. Where the number of meters warrant it, a well equipped repair shop and testing laboratory are desirable if not absolutely necessary. No meter should go out of the shop without being tested for accuracy and sensitiveness. The repair man should be thoroughly familiar with meters, and that he should be a mechanic, goes without saying. I consider it not only necessary to test all meters after repairing, or after they have been removed for any cause whatever, but think that it is desirable to test all new meters before they are put in service. This test need not be, except in cases where special information is desired, a very thorough or elaborate one. Three streams are all that are necessary—a full stream, then one representing about the ordinary faucet draft, and the third to represent what is the ordinary water closet leak, or say a $\frac{1}{32}$ of an inch orifice under 40 to 60 pounds pressure.

The decision as to the size, make and kind of meter for each particular service should be decided by the water department. The important factors controlling this decision would be, first, the quantity of water to be measured in any given time, and second, the rate at which this water will be drawn.

Fire protection, generally, should not be given in connection with the general water service, but should be by itself, whether metered or not, and in such cases the question of fire protection can be eliminated from the consideration of the proper meter for the particular service, which greatly simplifies the problem. There are, however, cases requiring the measurement of water where fire service must be taken into consideration. For instance where measurement of water for small town supplies is to be made. This problem is a rather simple one when the town is of sufficient size to warrant the setting of a meter of the Venturi type, but there are many cases where the conditions do not permit the use of a meter of this type. In such cases we are forced to consider the problem of a free flow for fire protection in connection with the accurate measurement of water where the draft varies very largely; or say from that of several fire streams in use in connection with the ordinary maximum draft of such systems.

To illustrate the importance of selecting the proper size, kind and type of meter for particular services, I give below two tests of experiments that I have made with various kinds of meters on particular services. The first is the comparison of the registration of three meters in tandem on an ordinary manufacturing plant, where the water was used for boiler purposes and for general use, i.e., in the taps, basins and closets throughout the factory. This plant was supplied through a 4″ service, which



PERCENT OF WATER REGISTERED

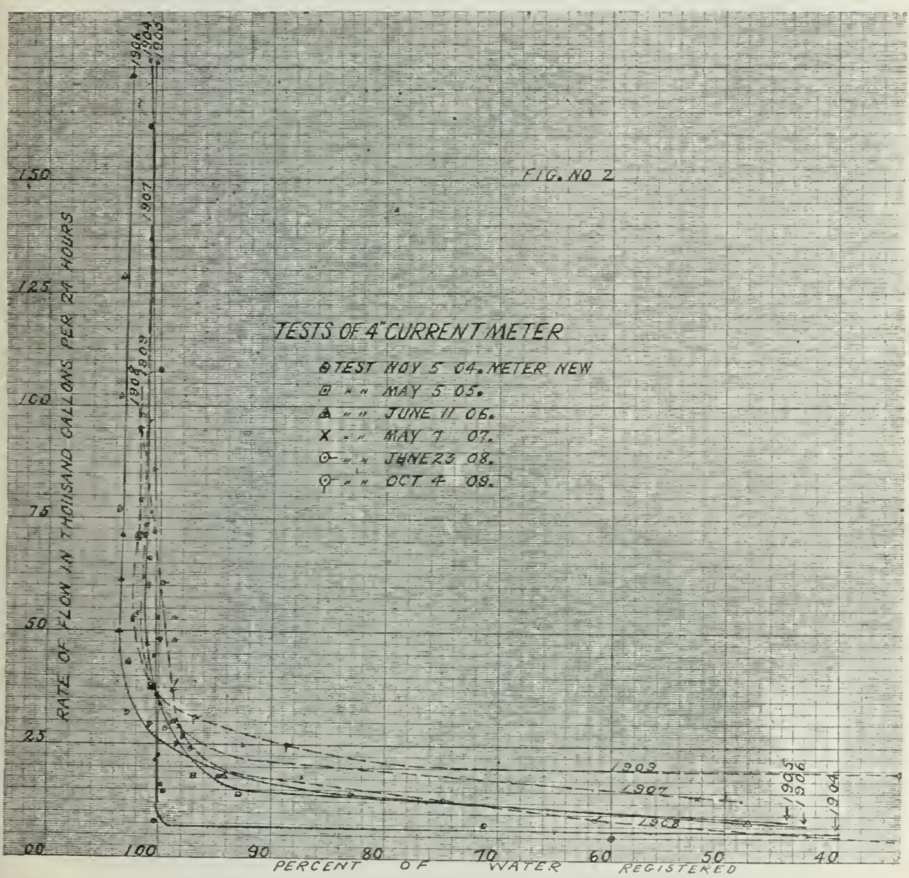


FIG. NO 2
TESTS OF 4" CURRENT METER
⊖ TEST NOV 5 04. METER NEW
⊡ " " MAY 5 05.
△ " " JUNE 11 06.
X " " MAY 7 07.
⊙— " " JUNE 23 08.
⊙ " " OCT 4 09.
RATE OF FLOW IN THOUSAND GALLONS PER 24 HOURS
150
125
100
75
50
25
00
100
90
80
70
60
50
40
PERCENT OF WATER REGISTERED
1906
1904
1905
1907
1908
1909
1909
1907
1908
1905
1906
1904

was at first metered with a 3″ Current meter. Afterwards a 2″ disc meter and a 2″ meter of a type recently put on the market were set in tandem with this 3″ Current meter. These meters are designated as A, B and C. A being a 3″ Current meter, B a 2″ disc meter, and C a new meter recently put on the market. The registration of these meters is given from July 16, 1909, to March 25, 1910. Fig. No. 1 gives the test of these meters when new.

Comparison of Three Meters

DATE	(A) AMOUNT CU. FT.	(B) AMOUNT CU. FT.	(C) AMOUNT CU. FT.
1909–June 16			
July 16	28,100	29,300	29,300
Aug. 20	33,000	35,400	35,500
Dec. 3	125,800	128,500	133,100
1910–Mch. 25	167,300	184,600	190,500

Assuming Meter C to have registered 100 per cent of the water passing through it, then Meter B for the first period of one month registered 100 per cent, and Meter A for the same period 96 per cent of the water passing through; and for the second period of slightly more than a month, Meter B registered 99.8 per cent, and Meter A for the same period registered 93 per cent of the total amount passing through them. For the third period, Meter B registered 96.4 per cent and Meter A 94.4 per cent. For the fourth period Meter B registered 96.8 per cent and Meter A 88.1 per cent. For a period of 8 months, Meter C registered on an average 48,500 cubic feet per month, which is a registration that would call for the use of a 1½″ meter. The total registration of these meters for the period of 8 months covered by the experiment is as follows:

TOTAL REGISTRATION.	DIFF. IN REGISTRATION.	PER CENT OF REGIST.
388,400		100
377,800	10,600	97.3
354,200	34,200	91.2

The curves showing the tests of these meters when new, Fig. No. 1, indicate very clearly why there is a difference in registration of 8 per cent between Meters A and C, and emphasizes the importance of having meters that are not only accurate upon large flows, but that are sensitive as well to small flows. Referring also to Fig. No. 2 which gives a series of tests of a 4″ Current meter similar to Meter A, the importance of having a meter that retains its sensitiveness in operation is brought out. Fig. 2 also shows that the meter originally set on this service was not suitable; first, that it was too large for the service and second that it was not sensitive enough, which condition generally goes with a meter of this size; in other words, a 1½″ meter would be better for the service than a 3″ meter.

As the second illustration of the importance of selecting the right size and type of meter for a particular service, I am giving a test made of a small town supply measured through a 4″ Current meter, Fig. No. 3. In this case a 2″ disc meter was placed tandem with the 4″ Current meter, and a 24 hour comparison made of the amounts registered by the two meters. The upper, heavy full line represents the registration of the 2″ disc meter, and the lower, heavy broken line represents the registration of the Current meter. Assuming that the disc meter registered 100 per cent of the water passing in 24 hours, the Current meter registered 70.3 per cent of that same quantity. This is a case where it was necessary to give fire service and still register the quantity of water. It is clearly evident from this curve that if the Current meter fills the first of these requirements, it does not fill the second, as it only registered 70.3 per cent of the quantity passed during the test. Referring to Figure No. 2, it is evident that this Current meter when new registered accurately a flow of 8000 gallons per 24 hours, but that even this good record does not take care of the conditions under which it is working, as the test in Fig. No. 3 shows that the minimum night draft is only slightly more than 4000 gallons per 24 hours. The curves on Fig. No. 2 show the performance of this meter by years. Other intermediate tests of this meter were made, but the curves given fairly represent its condition from year to year. These curves show that while this meter very soon lost its sensitiveness, it maintained its accuracy on flows above the rate of 30,000 gallons per 24 hours. It was

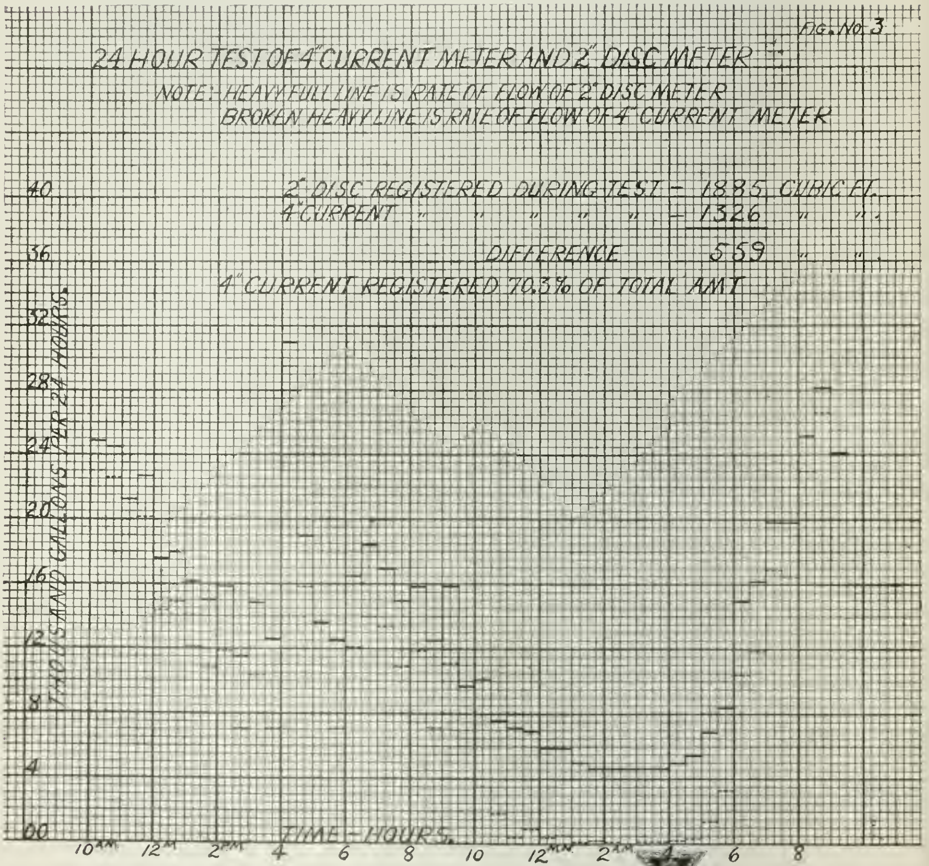


FIG. No 3
24 HOUR TEST OF 4" CURRENT METER AND 2" DISC METER
NOTE: HEAVY FULL LINE IS RATE OF FLOW OF 2" DISC METER
BROKEN HEAVY LINE IS RATE OF FLOW OF 4" CURRENT METER
2" DISC REGISTERED DURING TEST – 1885 CUBIC FT.
4" CURRENT " " " " " – 1326 " "
DIFFERENCE 559 " "
4" CURRENT REGISTERED 70.3% OF TOTAL AMT
40
36
32
28
24
20
16
12
8
4
00
THOUSAND GALLONS PER 24 HOURS.
TIME – HOURS.
10 AM
12 M
2 PM
4
6
8
10
12 MN
2 AM
4
6
8

overhauled and minor repairs made several times during this period, but never after its first test did it regain its original sensitiveness. The tests show that it is an excellent instrument for measuring water where the draft does not fall below the rate of 20,0000 gallons per 24 hours. The service under which it is working is not hard, averaging only from 30,000 to 60,000 gallons per month. Both of these curves show what not to do.

The meter best adapted for ordinary domestic or house service, taking account of first cost, durability, and cost of maintenance and repairs, seems to be the disc type, and from my experience with meters of this type, covering a period of some 10 or 12 years, I have not been able to formulate any rule that after a definite period of service, or after a definite amount of water has passed through a meter, that they should be removed for test. We depend rather upon the performance of the individual meter to determine this question. This means constant, careful and intelligent attention and consideration of the records of individual meters. In large plants where many thousand meters are in service this would seem to be an almost hopeless task, but I am very firmly convinced that it is the only proper way to handle the ordinary service meter.

I have in the past formulated rules for taking out meters after a definite period of service, or a definite amount of water has passed through them, and I have taken out a great many meters on this theory. The result of the tests of these meters has not proved in any way that this would be a proper rule to follow.

Fig. No. 4, which is given just as an illustration of some of the work that has been done along this line, gives the test of two ¾″ meters and two 1″ disc meters. The notes give the period of service and amount of water registered. Fig. No. 5 gives the test of four ⅝″ meters with the period of service and amount of water registered. Not any of these meters have seen especially severe service, but represent ordinary conditions. A meter that is working under especially severe conditions, i.e., a meter that is passing a great deal more water than ordinary service meter, needs special attention and careful watching, and should be replaced with a meter of proper size to take care of the conditions. The above statement in regard to removal and test of meters applies not to special cases, but to service meters in general.

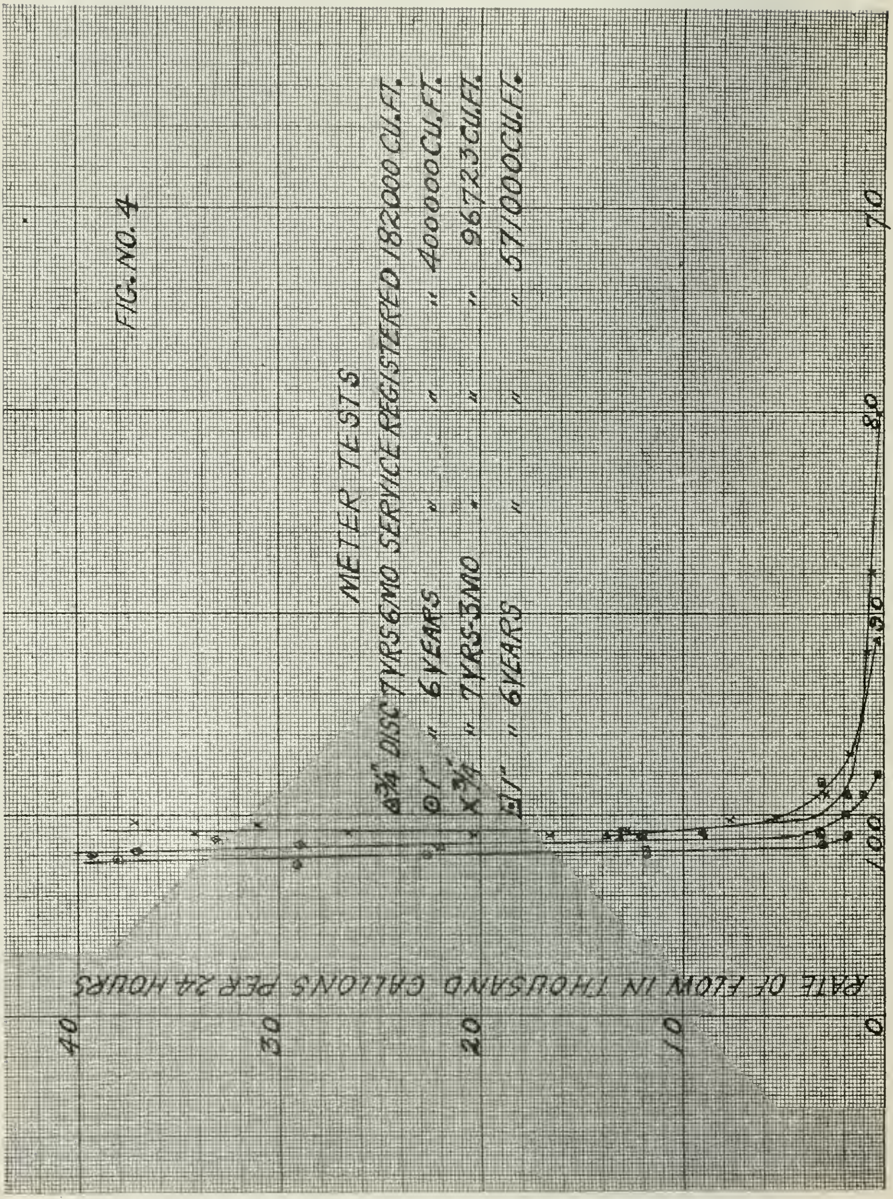


FIG. NO. 4
METER TESTS
⊘ 3/4" DISC 7 YRS 6 MO SERVICE REGISTERED 182000 CU.FT.
⊙ 1" " 6 YEARS " " 400000 CU.FT.
X 3/4" " 7 YRS 3 MO " " 967230 CU.FT.
⊡ 1" " 6 YEARS " " 571000 CU.FT.
70
80
90
100
PERCENT OF WATER REGISTERED
40
30
20
10
0
RATE OF FLOW IN THOUSAND GALLONS PER 24 HOURS

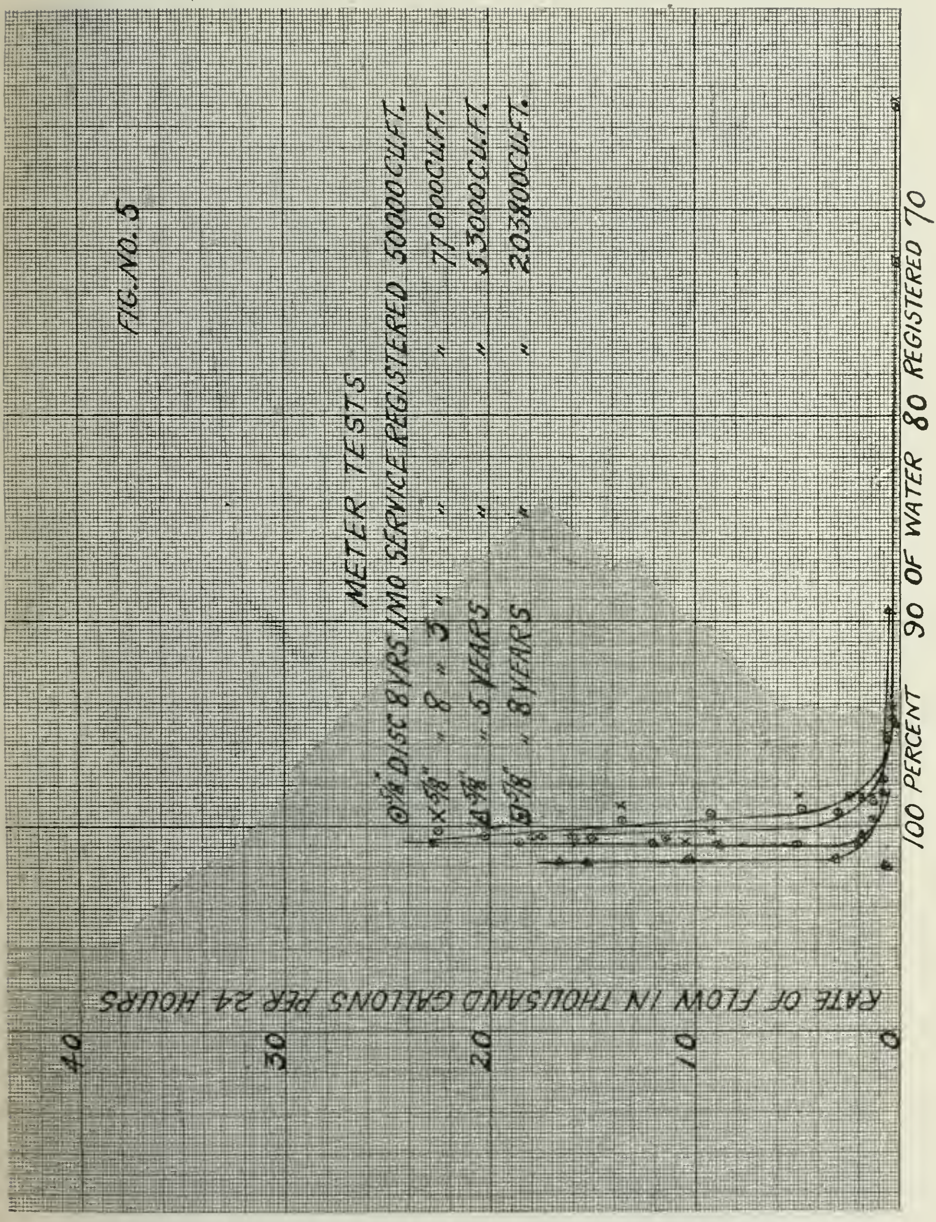


FIG. NO. 5
METER TESTS
⊙5/8" DISC 8 YRS. IN SERVICE REGISTERED 50000 CU.FT.
×5/8" " 8 " 3 " " " 77000 CU.FT.
△5/8" " 5 YEARS " " 53000 CU.FT.
□5/8" " 8 YEARS " " 203800 CU.FT.
100 PERCENT 90 OF WATER 80 REGISTERED 70
RATE OF FLOW IN THOUSAND GALLONS PER 24 HOURS
0
10
20
30
40

If the man whose duty it is to determine when a meter shall be removed for test has an intimate knowledge of how meters act under different conditions, and has some knowledge of the service and conditions under which each meter is operated, he can judge, if he has before him the performance of a meter over a period of one or two years, whether the meter is doing its work properly. To illustrate this point, I am giving the records of several individual meters, showing the gradual falling off in registration, which indicates a deterioration in the meter. These records were obtained from a plant that had been in operation for several years without proper supervision, and are examples of the condition that meters will reach when not properly watched, but conditions that would not obtain if the plant were well managed.

Record of Six ⅝-inch Disc Meters

DATES	QUANTITY REGISTERED BY QUARTERS, IN CUBIC FEET						DATES
	(1)	(2)	(3)	(4)	(5)	(6)	
1906–Oct.					14200		1906–Oct.
1907–Jan.			2300		22500		1907–Jan.
April		8900	2100		21100		April
July		13900	2000		14100		July
Oct.		6000	1900		11000		Oct.
1908–Jan.		4400	1700	8500	13300		1908–Jan.
April		3900	1200	6900	12300		April
July	1700	9000	600	1000	5600	3400	July
Oct.	1600	4100	900	4600	7700	2400	Oct.
1909–Jan.	1400	2100	1400	1100	10200	2800	1909–Jan.
April	1500	4300	1400	1000	5600	1600	April
July	6800*	1200	1000	21900*	4700	3600*	July
Oct.	6200	5900*	2200*	24600	15200*	4600	Oct.
1910–Jan.	5800	6500	2800	20400	18600	6500	1910–Jan.

* Indicates new meter.

In Column No. 1, the meter superintendent discovered that there were 20 people using water through this meter, and decided that the meter was not registering all of the water passing into the property. The record of the new meter which began in the July quarter, shows that this conclusion was correct.

In Column No. 2, there is, if the July quarters of 1907 and 1908 are eliminated, a fairly uniform falling off in registration.

The fact that the July quarter, 1909, was so low, taking into consideration the July quarters of 1907 and 1908, which were the high quarters of these years, calls particular attention to this record. The registration of the new meter for the October and January quarters succeeding fully justifies the conclusions drawn from these figures.

Column No. 3 needs to be examined by comparing corresponding quarters with different years to bring out clearly the deterioration in the meter.

In Column No. 4 the record shows that the meter should have been changed at least a year before it was.

Column No. 5 should be examined by comparing corresponding quarters of succeeding years. This brings out very much better the deterioration in the meter than by a casual examination of the figures in regular order, although such an examination in itself shows that there is something wrong. It is seen that the record of the new meter fully justifies the conclusion.

Column No. 6 is a short record, but brings out very clearly the falling off in registration of the meter and the necessity of carefully watching individual records.

As soon as the record of a meter indicates a falling off in sensitiveness or accuracy, it should be removed for test. But if only this method is used for determining when a meter shall be removed for test, we are likely to fall into error and lose revenue. For example, a meter may measure the ordinary draft due to customary use of water through a faucet, and still be not sensitive enough to measure a considerable leakage. The conditions in this service may run along for a time without any waste, and then a small leak may develop which the meter will not register, and the record of the meter will not indicate that there is leakage. To discover a condition like this, which is not at all an unusual one, again requires intelligent and careful attenton, and we must depend upon our meter readers to detect and report such leakage. It follows that a meter reader should have more knowledge and experience than simply to enable him to read a meter correctly. He must be trained to observe and report any unusual conditions which come under his notice. We have found that the use of the aquaphone, simply the adaptation of an ordinary telephone receiver, will disclose a leak which is not recorded by the meter, and we have furnished these phones to each of our meter readers. It is only a moment's work to test the pipes for leakage when a meter is not moving. Another important aid to the man who is responsible for the meters is a knowledge of the conditions under which the meter is working, or in other words, a knowledge of the character of the premises supplied through the meter and the amount of water that should be used. This would seem to be an almost impossible task for the man who is looking after ten or fifteen thousand meters, but it is not so difficult or impossible as at first appears, if the man is familiar with the territory generally, and occasionally himself goes out and makes inspections, and has under him a competent force of meter readers. It is necessary to have, besides a general knowledge of conditions, definite knowledge of each particular case, and to have this information available. We have a blank form on the back of our meter reading slips for this information, Fig. No. 6. These inspection blanks are filled out from time to time by the meter readers with the essential information concerning the property, and this information is transferred to new slips when they are made out, so by merely turning the slip over, the meter man has before him the necessary information by which to judge the performance of the meter.

Fig. 6

Stories..
Families ....
Baths..
Water closets..
Sprinkle ....Feet-Front
Horses.........................Autos....................
Business ....
Motor ....
....
Rate ....
Remarks..
....
....
....
....

Signed....................

When a doubt is raised in the meter superintendent's mind to the accuracy of a meter (after considering its record) which is not strong enough to warrant its removal, or the question of accuracy of the meter is brought up by the consumer, a rough test may be made of the meter in place by drawing one foot of water from a faucet and measuring it in a quart measure or any other convenient receptable. This test is inexpensive and easily made by a meter reader, and often proves to the satisfaction of the meter superintendent or to the consumer the accuracy of the meter, or on the contray it may develop the information that the meter needs removal for overhauling. The meter reader also, if he understands his business, can readily test the meter for sensitiveness. Note of the result of any such test should be indicated on the side of the meter reading slip for future reference.

It is second in importance only to watching the registration of meters to see that the meter itself, as set, shall be kept in repair as far as external conditions are concerned. Such items as broken glasses, broken seals, broken register-box covers, etc., should be reported at each reading by the meter reader, and these minor repairs attended to promptly. A meter with a broken glass or broken seals is a great temptation to the property owner. It is a comparatively easy matter to pull off the hands of a circular reading dial and reset them so the reading of the meter will be very materially affected, or to take the dial off and run it back a few thousand feet. Where meters are read only once in three months, it is a simple matter, if the meter is not sealed, to take it out and reset it backwards, leaving it in this position for a month or six weeks, and changing it back to the proper position just before the time for the meter reader to come around. It is an excellent idea, where there is any suspicion that the meter is being tampered with, to take several intermediate readings. These are quite apt to enable one to discover any irregularities.

Meters larger than 1″ in size need different treatment in their care and attention than smaller meters. They are usually used for measuring water for other than purely domestic purposes and the conditions under which they ordinarily work are quite different from that under which the service meter is operated. The rate at which water is used from time to time is not so uniform as in domestic use of water, and does not furnish so sure an index by which to judge the condition of the meter as in the case of the service meter. These meters should be tested at regular intervals, varying with individual cases, from a period of six months, or perhaps in exceptional cases shorter periods, up to a year, depending upon the work that the meter is doing. If a meter is removed for such tests frequently, it proves to be very expensive, and it is advisable to have the meter so set that it may be tested in place at comparatively little cost and trouble. It is perhaps feasible, but not necessary, to remove 1½″ and 2″ meters for test without undue expense and trouble, but meters above these sizes should always be arranged with valves on each side with a tap or tee between the valve and the outlet side of the meter, so that the meter may be tested without removing, and in order not to disturb the supply to the customer while such test is being made, meters above 1½″ and 2″ should also be by-passed. We have all of our meters 3″ in size and above so arranged, and test them at least twice a year. The test is made by passing water through a 2″ disc meter and comparing the registration of the two meters. The 2″ meter used for this purpose is tested in the regular meter testing plant often enough to insure that it is registering accurately. The records of these tests are plotted on cross-section paper, and show at a glance the condition of the meter at the time of the last test, and the series of tests over a long period show the effect of the service upon the meter, and indicate what may be expected of meters of similar type upon similar services, and to a less degree, perhaps, are indications by which to judge of the condition of other meters.

As an example of the way meters larger than 2″ are handled by us, I am giving a series of tests of 4″ meters on a pipe supplying a large group of county institutions, Figs. Nos. 7 and 8. Referring to Fig. No. 7 and the curve showing the test on July, 1902, we have an illustration of how bad a meter may get and still register. The meter to which this test applies was at once removed, and another meter of the same type set. The other curves on this chart show tests of this meter at various periods of its career. The test in March, 1903, the first test after its installation, shows a curve of 99 per cent accuracy, and that the meter was sufficiently sensitive to take care of the conditions under

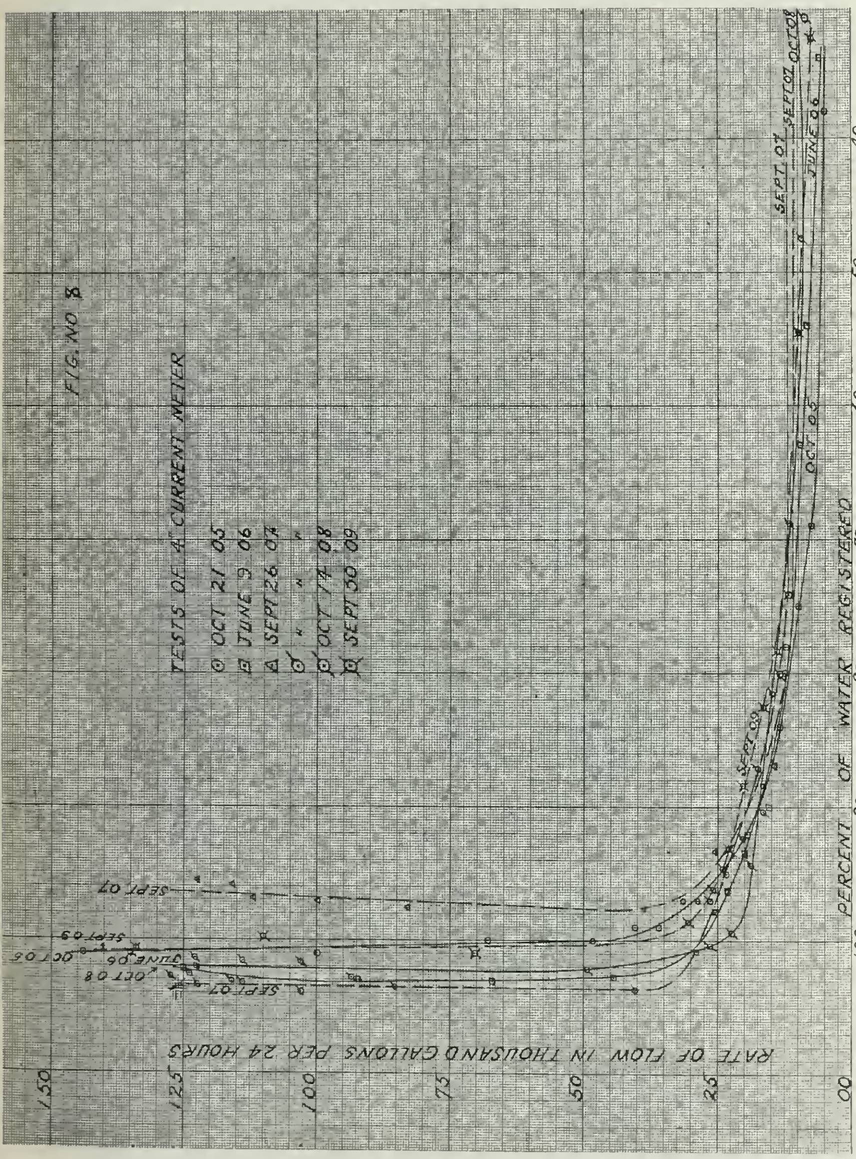


FIG. NO 8
TESTS OF 4" CURRENT METER
⊙ OCT 21 05
⊡ JUNE 9 06
△ SEPT 26 07
" "
OCT 14 08
⊠ SEPT 30 09
PERCENT OF WATER REGISTERED
40
50
60
70
80
90
100
RATE OF FLOW IN THOUSAND GALLONS PER 24 HOURS
00
25
50
75
100
125
150
SEPT 07
SEPT 09
OCT 05
JUNE 06
OCT 08
SEPT 07
SEPT 07
SEPT 07
OCT 08
JUNE 06
OCT 05
SEPT 09
STANDARD CROSS SECTION ... KEUFFEL & ESSER CO NEW YORK

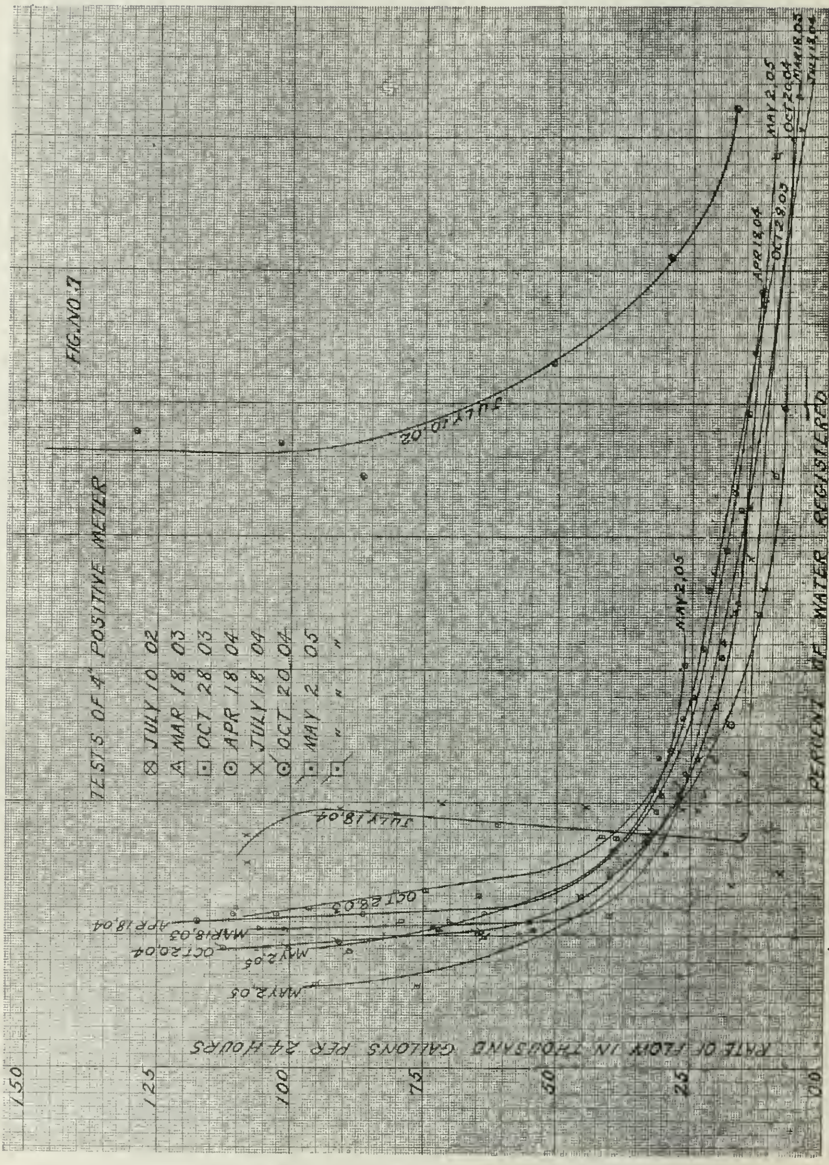
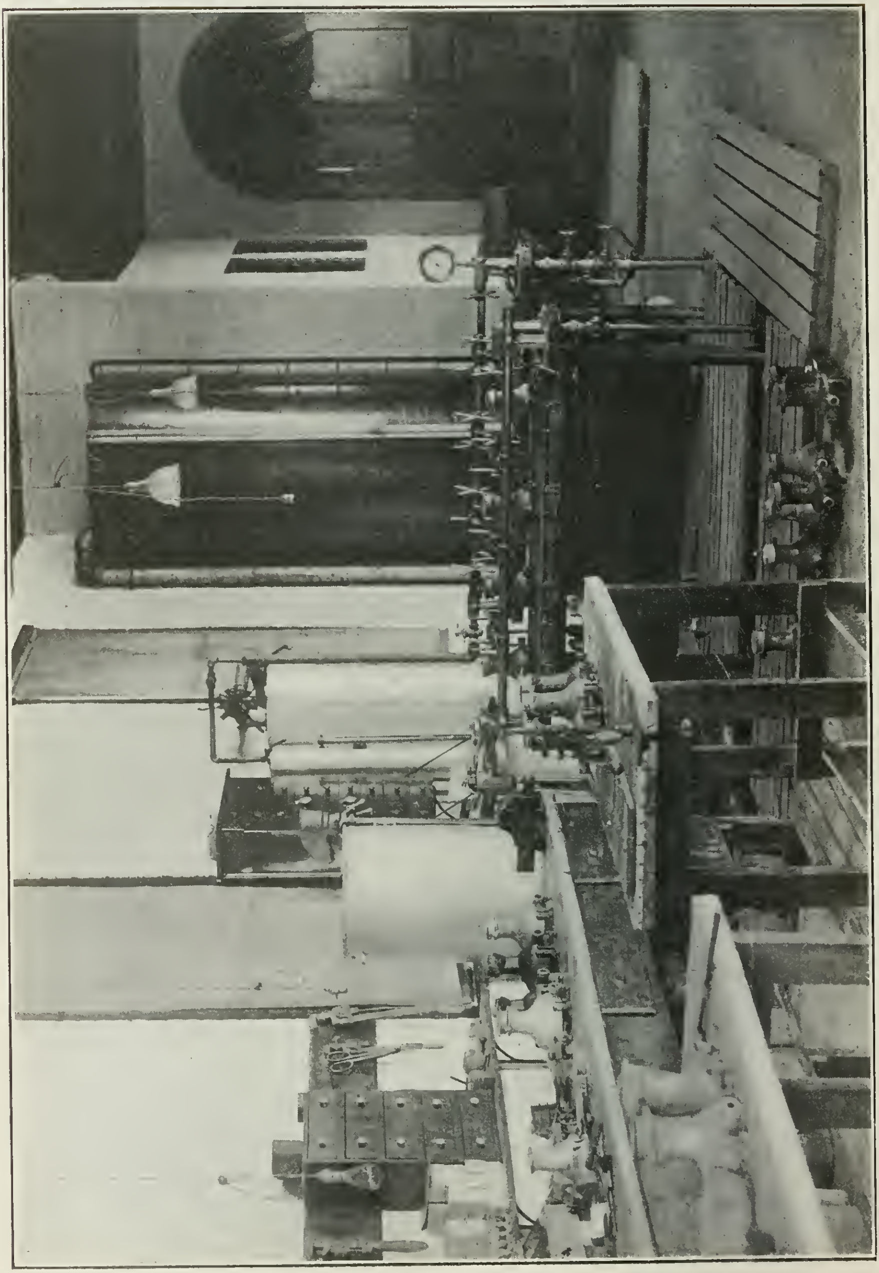


FIG. NO. 7
TESTS OF 4" POSITIVE METER
⊠ JULY 10 02
△ MAR 18 03
⊡ OCT 28 03
⊙ APR 18 04
✕ JULY 18 04
⊙ OCT 20 04
⊡ MAY 2 05
⊡ " "
JULY 10 02
JULY 18,04
OCT 28,03
APR 18,04
MAR 18,03
OCT 20,04
MAY 2,05
MAY 2,05
MAY 2,05
APR 18,04
OCT 28,03
MAY 2,05
OCT 20,04
MAR 18,03
JULY 18,04
PERCENT OF WATER REGISTERED
40
50
60
70
80
90
100
RATE OF FLOW IN THOUSAND GALLONS PER 24 HOURS
150
125
100
75
50
25
00

which it was working, the rate of flow being about 125,000 gallons per 24 hours. The test in October, 1903, shows a falling off of about 3 per cent in accuracy, and a corresponding falling off in sensitiveness. No repairs were made to this meter after this test and the next test in April, 1904, shows a slight improvement over the test of October, 1903; the sensitiveness being practically the same, but an improvement of about 1 per cent in accuracy. The next test made in July, 1904, shows that the meter was only registering about 91 per cent of the water passing through it. At this time the meter had stopped registering because of a broken intermediate gear, and this test was made after a new gear had been put in, and indicates that the general condition of the meter was accountable for the under-registration. It was brought back to accuracy by changing the gears. It was tested again the following October, when it developed an accuracy within 1 per cent of perfect, and with the sensitiveness about the same as it had been on previous tests. The test in May, 1905, showed a falling off in accuracy, and a rapid falling off in sensitiveness. After this test the meter was thoroughly cleaned, new intermediate gears put in, and a test made on May 25, 1905, shows the results of this cleaning. This meter had been so uncertain and troublesome that it was changed in October, 1905, and a Current meter set in its place. The tests of this meter are shown on Fig. No. 8. The curve for October, 1905, is the test of the meter when new. The curve of June, 1906, was the first test after being set. This curve shows an increase in percentage of registration on higher flows and an increase in sensitiveness, a not unusual condition after a short service. The next test of this meter September, 1907, shows a sharp falling off in both accuracy and sensitiveness, and the meter was brought back to its normal condition, both as to accuracy and sensitiveness by cleaning. During the period between this and the 1908 test a very slight change is shown. The 1909 test shows simply a very gradual falling away in percentage of registration and sensitiveness. The daily average rate of flow registered by this meter during this period was about 225,000 gallons, and the total amount registered up to the time of the test was 40,000,000 cu. ft. and the meter has proved much less troublesome and more suited to the work to be done at this particular point than the example given in Fig. No. 7.



Corner of Meter Testing Laboratory

This paper is not intended as a complete discussion of all phases of the subject, but rather as a short discussion of a few of the practical questions pertaining to meters, and it is hoped that it will create such an interest in this subject that it will be continued and enlarged upon by members of the Association in both the discussion and in future papers.

Acknowledgement is hereby made of the valuable assistance in the preparation of this paper of William R. Edwards the superintendent of the meters for our various Companies.

DISCUSSION.

President Mason: Gentlemen, this paper is before you for discussion. The previous paper having been printed in the Advance Copy, of course it has been examined by those interested in the question; therefore, you are as well prepared to discuss the two together as though the other had been read.

Mr. Theo. A. Leisen: I would like to ask the last speaker about how many meters are read by each meter reader, how many are handled by each reader?

Mr. A. W. Cuddeback: From 110 to 150 is supposed to be an average day's work, working eight hours. There are certain places where a man cannot read as many as 100, and a few places only where he can go as high as 140; the average is perhaps 120.

Mr. J. M. Diven: Are the meters set in boxes at the curb line, or inside of the buildings?

Mr. A. W. Cuddeback: All our meters are set in the cellar practically all.

Mr. Beekman C. Little: I would like to ask what are the highest wages paid the meter reader; also, if changing the routes does not waste a good deal of time by the men not being accustomed to the locations of the meters?

Mr. A. W. Cuddeback: I think the answer to that question was made when I said we endeavored to keep our meter readers at that business as long as we could, so that they get familiar with the entire plant. While our meters are scattered in three towns, we have a quarterly reading each month; our meter reading force is not very large but they are kept busy all the time, and they get familiar with the territory as a whole. We have about 12,000 meters.

Mr. Theo. A Leisen: I might say as to changing the routes, that we have been following that practice in Louisville for the last year or so, with very good success. We do not believe that we lose any time in that way because all of the different meter readers become familiar with all of the routes, and if for any reason one happens to be sick or leaves it does not necessitate the immediate breaking in of a new man over his route.

Mr. E. E. Davis: We have four readers, one following the other. One man reads the meter this time, and another man the next time. We deliver bills quarterly but read the meters monthly.

Mr. A. W. Cuddeback: We have a certain number of meters which we read monthly. We started out to read them all monthly, but we found that it was not a matter of sufficient importance to make it the rule.

Mr. W. H. Randall: While I think that the writer of the paper went very carefully into the subject, perhaps it would not be amiss to draw your attention to the position in which we in Canada have recently found ourselves owing to the passage of a bill in the House which slipped through before the municipality knew anything of it, and by the terms of which we are compelled to have all meters inspected by a government inspector, who places a seal upon them after which the meter cannot be touched again by any member of the municipality until the government inspector is present. I need not tell you that we put up a pretty strong fight against this, and the City Engineer of Toronto, the Deputy Engineer and myself had a long conversation with the government officials and tried to show them the impossibility of such a bill being practical. The bill nevertheless passed. For years it had been the custom that when meters were brought into the shop and repaired the dials were set back to zero. The government officials were strongly opposed to that, and since then we have been in the habit when meters are brought in for repairs of keeping the readings and sending them out again after repair just as they read when taken out. I think care should be used as to care of dials, because that seems to be a very strong point on our side of the line and great objections are taken to the fact that meter dials are liable to be changed by the readers and others. They object to the seal being broken and the dial taken off when repairs are made unless the meter is properly tested again before being sent out.

MR. A. H. WEHR: Does not the gentleman consider it good practice that the meter should be tested and sealed in the shop and should under no circumstances be opened on the ground, but only in the shop?

MR. A. W. CUDDEBACK: I should certainly consider that good practice; but that applies, of course, to the seal on the register box only. We use an ordinary wax seal.

LAYING 48-INCH STEEL PIPE

NEW WATER SUPPLY OF SPRINGFIELD, MASS.*

July 6, 1910

ALLEN HAZEN

The old water works in Springfield were built more than thirty years ago. Water was taken from a reservoir, called the Ludlow Reservoir, formed by building two dams at the ends of a valley containing a wide marsh, forming a large and rather shallow reservoir, with a limited catchment area. The Ludlow water in the years that followed became the most notoriously bad smelling reservoir water in the United States. As a matter of fact, it was not the worst, for I know of several reservoirs in which the growths of organisms and the resulting tastes and odors were worse than in the Ludlow reservoir. But the people of Springfield were critical; the water was studied carefully by many engineers and chemists, beginning with the late Prof. William Ripley Nichols, who was a pioneer investigator of this subject. Many long reports were made and printed, and it became the most notorious of the bad smelling waters, if not really the worst.

The quantity of water available from Ludlow was limited, and although as the years went by several neighboring streams were diverted to it by canals and pipe lines, there was not enough water to be had to serve a rapidly growing city for any great length of time in the future.

In 1904, after long continued and elaborate experiments upon different kinds of filtration, it was proposed to filter this water and otherwise improve the supply, and the writer was engaged with this end in view; but when the matter was taken up it was found that in addition to the filter plant many reconstructions and additions would be required, and that when everything was carried out to put the supply in thoroughly good shape an expenditure of fully $2,000,000 would have been made, and with that done only about fifteen million gallons of water per day on an average would be available in a dry year.

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*Lecture illustrated by lantern slides.

It was then suggested to the Water Board and to the City Council that instead of spending so much money upon the reconstruction of an old source of supply, it might be better to put it into a new supply, and to retain the old one as a reserve.

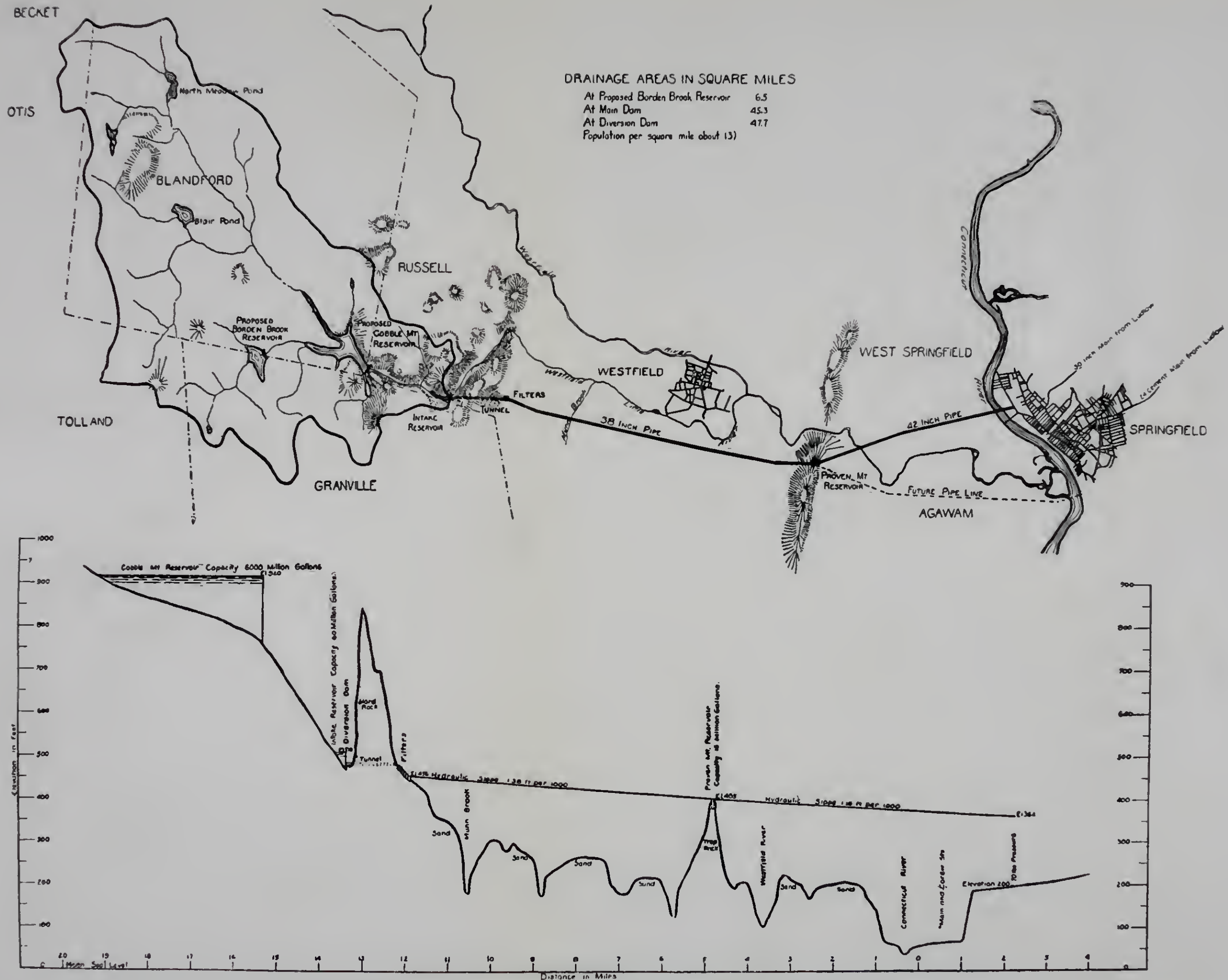
There were several possible sources for a new supply. Indeed, several engineers had reported upon the subject and had recommended one of these. The State legislature had more than once refused to grant permission to take this supply, and this refusal had been a large element in bringing the city to attempt the rehabilitation of the old Ludlow works.

A rapid preliminary investigation indicated possibilities in a mountain stream called Little River not fully recognized in previous investigations. A further survey of it proved favorable, and the city petitioned the legislature for right to take and use it. This right was ultimately granted and the construction of the new supply was finally authorized in 1907. Since that time the new works have been built and put in service.

The main features of the construction of the works for the new supply were shown by the lantern slides, and were described in connection with them. The following description is written to take the place of what was said and to give a very brief idea of the nature of the proposed works.

Springfield is on the eastern bank of the Connecticut River. The old Ludlow supply was some twelve miles to the eastward. The new Little River supply is a slightly greater distance to the westward, and is therefore as far away as possible from the old works. The new works were therefore entirely independent of the old works, and there was an opportunity to make a new design, not hampered by adaptations to the old works, the conditions being in this respect similar to those at New Orleans, which Mr. Earl described to us last night.

In another respect the Little River supply is very different from the new supply of New Orleans. The Little River catchment area is elevated, all of it being more than 500 ft. above sea level, and the main storage reservoir, just filled, being at an



GENERAL PLAN LITTLE RIVER SUPPLY, SHOWING NEW SOURCE AND MANNER OF UTILIZING IT.

elevation of 1070 ft. above sea level, and about 1000 ft. above the level of the business part of Springfield.

The catchment area of Little River at the point of diversion is forty-eight square miles, and from that can be drawn ultimately at least thirty-five million gallons of water per day in a dry year, and further the Ludlow supply will always be available to the extent of its capacity. The Ludlow supply, to the extent of eight or nine million gallons per day continuously in a dry year, and to a greater extent for periods that are not too long, can be satisfactorily used through the summer, in connection with the intermittent sand filter which was constructed in place of the more permanent works that had previously been considered at about the time that the new supply was authorized.

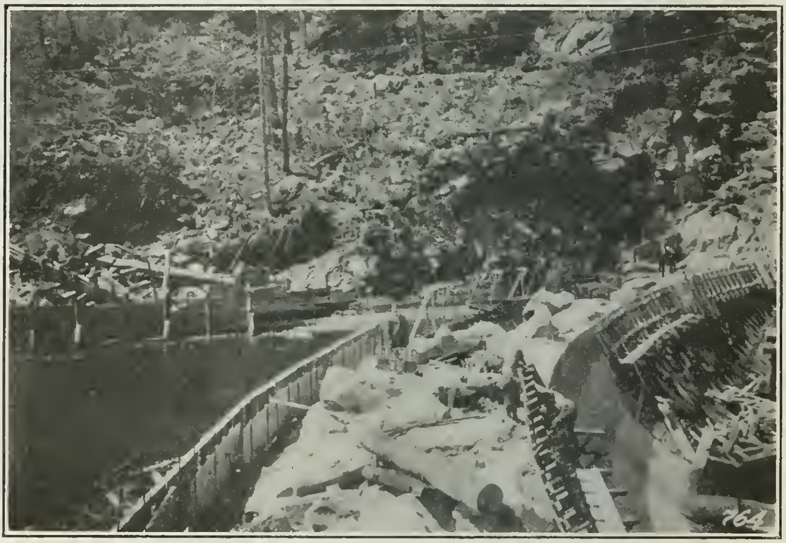
This intermittent sand filter was built because it was felt that the value of removing, or even greatly reducing, the tastes and odors for the remaining years that it would be necessary to use the Ludlow supply, fully justified the cost required for constructing and operating it, and I may say it has been a source of great satisfaction to the people of Springfield, and I think that no one has ever regretted the money that was put into it.

The capacity of the first works for the development of the Little River supply is called officially fifteen million gallons per day, but actually all parts of the works have been calculated upon so liberal a basis that at least eighteen, and possibly twenty, million gallons per day may be drawn from it even in a dry year.

The intake is in the Little River gorge, a narrow valley five or six miles long, in which the stream has a fall of more than one hundred feet per mile. Both sides rise to a height of four hundered feet or more above the stream. The north slope is covered with laurel, affording a beautiful sight when in bloom. The native timber, largely hemlock, had been cut out for the most part many years ago, but at the place where the intake dam was built the topography was so rough that it had not been considered worth while to build a road to get out the timber, and so the work was located in virgin forest, with great hemlocks four feet and more in diameter.

The first work was to build a road nearly two miles long, with grades ranging up to 18 per cent, often blasted out of solid rock. This made the site accessible.

An intake dam in the form of an arch, with a radius of 170 feet, of concrete filled with boulders taken from the bed of the stream, was built to raise the water level about fifty feet. It was necessary to carry the foundation for this dam about twenty-eight feet below the river level, at which point solid unbroken ledge was obtained. The rock is a form of mica schist almost as hard as granite, and grading into a true granite in places. The dam is two hundred and seventy feet long at the top and forty-six feet thick at the bottom and ten feet at the top, and contains 12,591 cubic yards of masonry.



INTAKE DAM UNDER CONSTRUCTION.

The upper side of the dam, near the top, is curved to prevent the possibility of ice thrust at the extreme top. During the past winter ice formed against this top solidly to a depth of five feet. This great depth may be accounted for in part by the fact that the narrowness of the gorge and steepness of the hills lets but little sunshine reach the reservoir in winter, and it may also have been due to frazil or floating anchor ice coming down with the water from the rapid stream above, and rising to the surface in the still water of the pool, above the dam, and then freezing into a solid mass of ice. The intake dam is not in a very accessible place in winter when the sides of the gorge and road are covered with snow and ice.

The spillway of the dam is one-hundred and fifty-five feet long, to carry the largest flood flows. It was desired to get a record of the quantity of water flowing in the river with all possible accuracy, and it was felt that the ordinary flows could not be measured with the desired degree of accuracy on so long an overflow. For this reason a measuring notch twelve feet wide was built in one of the abutments, in which notch a standard weir was built, and ordinary flows will pass over this and will be measured with a greater degree of accuracy than could be reached with the main overflow. This notch and weir, therefore, were built for the sole purpose of getting a more accurate record of the stream flow.

INTAKE DAM NEARLY COMPLETED, SHOWING INTAKE AND OPENING FOR MEASURING WEIR.

The greatest depth of water over the dam since its completion last fall has been a little less than three feet. The reservoir covers 7.7 acres to an average depth of twenty-one feet, and holds fifty-two million gallons, of which forty million are available.

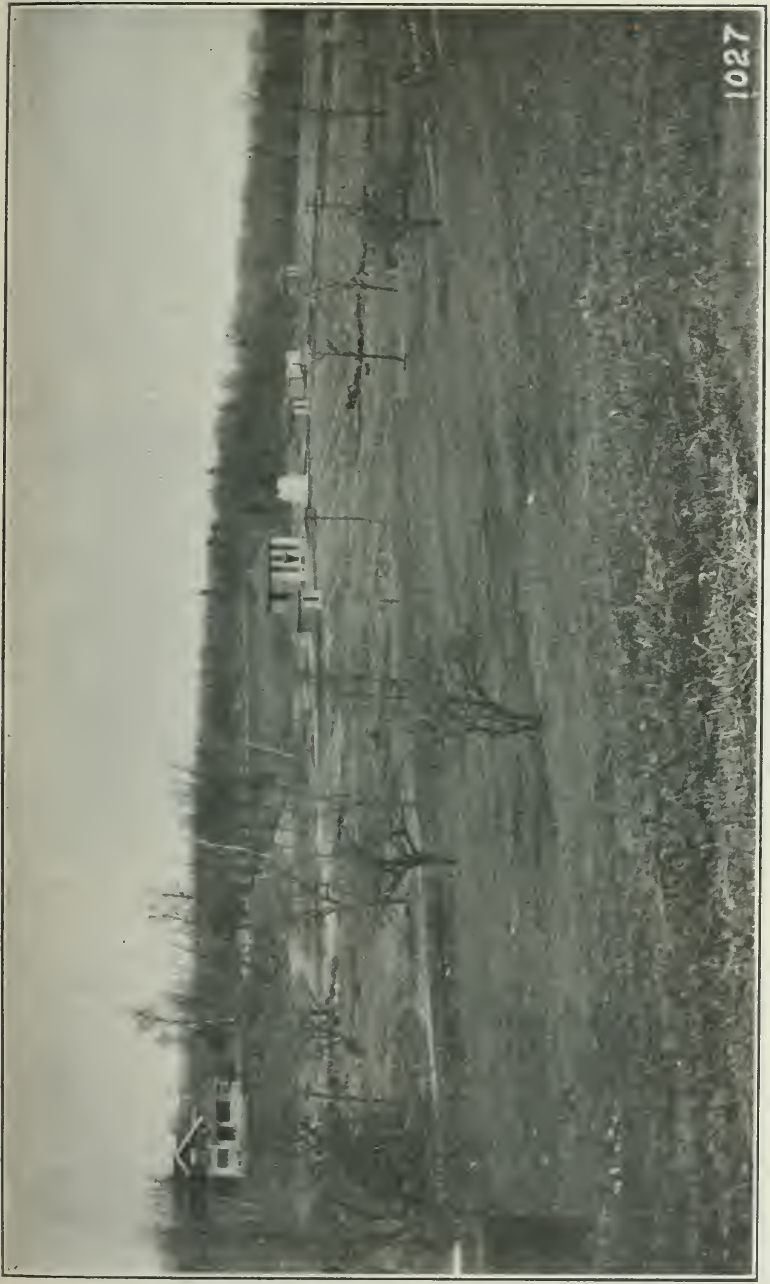
Water is taken from the dam through an intake and gatehouse built in one of the abutments, and passes through about six hundred feet of fifty-four inch steel pipe laid on the side of the gorge, and then turns sharply and enters a tunnel blasted through solid rock for a distance of 4530 feet. The average slope of the rock at the tunnel entrance was more than 45°, so that the tunnel 300 feet from the portal is more than 300 feet below the surface of the ground.

The tunnel was lined throughout with concrete placed against steel forms, making an opening of uniform section and smooth sides all the way. The lining might have been omitted from those parts of the tunnel where the rock was soundest and best, but it was felt that with the lining the work would be more stable and especially that it would be more easily cleaned and for this reason it was lined throughout.

The finished height is six feet three inches and it is five feet wide and capable of carrying over fifty million gallons of water per day. This is a considerably larger quantity than can ultimately be taken as a dry-year average from Little River, the larger capacity being provided to allow water to be drawn at higher rates to meet extreme rates of consumption considerably exceeding the average rate.

On leaving the tunnel the water passes through a further length of fifty-four inch steel pipe, with a Venturi meter, which measures and records all the water diverted from Little River, to a receiving basin holding thirty-nine million gallons, with a flow line 490 feet above tide. This basin is formed by an earth dam about 700 feet long, and with a height of over forty feet, across a natural valley. The area is 8.3 acres and the average depth fourteen feet. A circulating conduit is provided so that the water all enters at the most distant part of the basin and is drawn to the filters from the gate-house at the dam. From this reservoir to the filters is a drop in level of twenty-five feet.

The reservoir outlet pipe goes to a building which serves at once as a gate house, and office and laboratory. In the basement of this building are arrangements which allow the water to be drawn through a water wheel furnishing power for electric lights and other purposes, or through a large aerating fountain, or it can be drawn through a throttling gate. Whichever way is used the water finally finds its way to the pool of the aerating fountain, a concrete structure fifty feet in diameter with an over-



GENERAL VIEW OF FILTERS, SHOWING AËRATION FOUNTAIN, OFFICE AND LABORATORY BUILDING, AND SUPERINTENDENT'S RESIDENCE flow. From this it passes to the six covered sand filters, each with an area of half an acre.

The filters are built with the idea that in the near future at least the rate of filtration will not exceed six million gallons per acre daily, or three million gallons per day for each filter, but this limit is not regarded as definite or final. The piping is all suitable for a higher rate and actual experience in the operation of the filters under laboratory control will serve to show just what can be done and what results obtained at different rates of filtration, so that the question of rate may be reconsidered on the evidence of actual experience when the additional filters for developing the whole capacity of the supply are added at some time in the future.

Filtering a supply of this character is something of a novelty in this country, although it has frequently been done in Europe. The catchment of the Little River, in a mountainous country, has but little population upon it, and but few cities have better water than the water as it comes through the aerating fountain. If the works had been built a few years earlier unquestionably the pipes leading to the city would have been connected directly to the tunnel, and the water would not have been filtered, but when this design was made the people of Springfield had already become acquainted with the radical improvement worked by the intermittent sand filter on the Ludlow supply, and with this experience before them there was a strong sentiment in favor of filtering the new supply at the outset, and as this course was suggested and approved by the engineers and by the Water Board the filters were installed as part of the original equipment.

Filtering in this way through sand filters at a relatively high rate requires only a moderate capital investment, and the operating expense is small because all the operations are simple and labor saving devices are provided as far as possible. The added cost of the whole plant, because of filtration, does not exceed $300,000.

Filtration removes whatever turbidity there may be in the Little River water. It reduces the odor, and with slight chemical assistance occasionally, will insure at all times the delivery in Springfield of a water that is bright and sparkling.

The filtered water is stored in a covered pure water reservoir about twenty-six feet deep, holding seventeen million gallons, or about a day's supply. Instead of placing this reservoir directly at the filters it was placed about seven miles nearer the city on the top of a ridge of trap rock known as Provin Mountain at a suitable elevation to give the required pressure in the city.

The pure water reservoir is covered to prevent the growth of organisms in it, which otherwise would produce tastes and odors. By covering it the water is retained of the full degree of purity that it leaves the filters and is delivered without organic deterioration.

In another respect there is deterioration because the water takes up some iron from the pipes, and especially some sediment in the old pipes of the distribution system, and for this reason the water as delivered in the city is not as clean as the water leaving the filters and pure water reservoir. This deterioration seems to be unavoidable with cast iron pipes, and especially with an old system that has been long used for dirty water.

LAYING 48-INCH STEEL PIPE.

The effect of the old deposits is being minimized as far as possible by systematic flushing, that is, by taking each line of pipe by itself, shutting off the lateral connections and opening sufficient hydrants on the ends to produce a velocity through it at least twice as great as any velocity likely to be reached in ordinary use. Flushing of this kind removes all loose material that can be disturbed by such a current, and that which resists it is not likely to come loose again by the ordinary flows.

A forty-two inch lock bar steel pipe leads from the filters to the pure water reservoir and thence to the city. The total lenght is 11.6 miles; the plates range from one-fourth inch to seven-sixteenths inch in thickness according to pressure. The greatest pressure carried is about 150 pounds and one of the pipes was tested experimentally to a pressure of 1050 pounds, or seven times the working pressure. The total weight of the forty-two inch steel pipe was 5100 tons.

A Venturi meter is placed on the pipe leading from the reservoir so that a continuous record is kept of the amount of water used in the city, and also of the rates of draft during the different hours of the day. This record is of great value in showing the times and amount of any unusual drafts. It shows the maximum and minimum rates of draft each day and the range between the night draft and the day draft. Since the supply has been in use the rate of draft falls after midnight frequently to as low a rate as four or five million gallons per day, and rises in the middle of the day to a rate of eighteen or twenty million gallons per day or more. In other words, the maximum rate of draft is four or five times as great as the minimum rate. These conditions indicate a minimum amount of leakage from the pipe system and plumbing fixtures of the city. With more leakage the night rate of draft would be higher in proportion.

In crossing the Connecticut River the forty-two inch line was divided and two thirty-inch lines of steel lock bar pipe, each seven-sixteenths inch thick were used. These were placed thirty feet apart on centers so that a leak or accident in one would be less likely to endanger the other. The pipes were riveted together and caulked, forming lengths of about three hundred feet formed to fit accurately the contour of the bottom of the river, and were then sunk between double rows of piles until they rested upon cross timbers bolted to the piles. The different lengths of pipe were bolted together by means of extra heavy flanges with a narrow lead gasket, the bolts being drawn up until the lead gasket was flattened out and deformed, making an absolutely tight joint between the flanges. The pipes are surrounded by concrete placed in bags throughout their entire length. The projecting piles are cut off and the trench backfilled. The piles and cross pieces serve to support the pipes so that in case of wash and change in the river bed they will still be supported on the piles.

The river at the point of crossing is about nine hundred feet wide, but the whole structure extends some distance on either shore, and the total length is one thousand one hundred and fifty feet. The greatest depth of water at low water was twenty-two feet and the top of the pipe is three feet or more below the bed of the river.

One line of thirty-inch pipe was completed across the river so that it could be put in service in December last. The second line was begun, but winter prevented its being finished and it will be completed this year.

The natural flow of the Little River is not sufficient to maintain the supply in dry weather. Two or three miles above the intake dam there is a site for a very large dam to form an impounding reservoir that will hold the winter and flood flows and make them available in dry times. A reservoir can be built at this site large enough to develop all the water that can be advantageously taken from the catchment area, but the construction of this reservoir at this time was unnecessary and would have involved altogether too large an expense.

For present purposes to develop one-half the water to be ultimately obtained a reservoir was built upon a tributary called Borden Brook, where an excellent site was found. Borden Brook reservoir holds two and one-half billion gallons, more than sufficient to make available the fifteen million gallons per day to be obtained by this development. The reservoir covers two-hundred and sixteen acres and is formed by an earthen dam seventy-eight feet high and six hunderd feet long. Most of the reservoir bottom was clayey or sandy meadow land surrounded by abrupt slopes on all sides, so that there is no shallow flowage in any part of the basin. The average depth is thirty-five feet.

An old brick house with four hundred acres of land was bought at the outset. The house served the resident engineer until it was necessary to tear it down to make way for the rising water, for the site is now under some fifty feet of water.

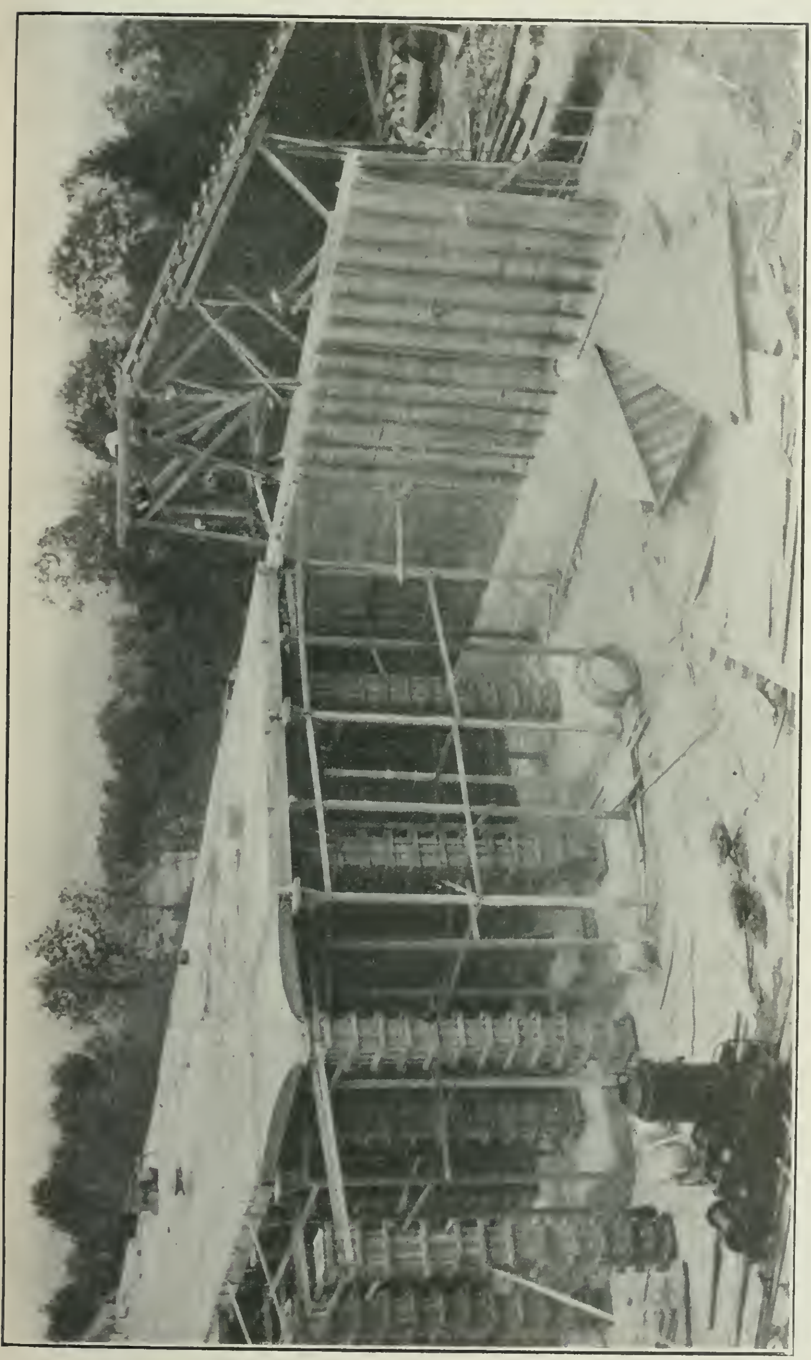
The material for the dam is a material locally called "hard-pan," a mixture of clay, sand and gravel, forming in its natural state a hard mixture, and compacting as we found under a steam roller to a mass of the greatest solidity and tightness. The whole dam is formed of this material.

In building the dam a concrete outlet tunnel was first built on a ledge at one side of the stream and the water was diverted through this, which allowed the natural bed of the stream to be drained and the dam to be built in it. This outlet tunnel was plugged in a way previously arranged at the very last closing the dam. The water is drawn through an outlet gate house at three different levels as desired connecting through a shaft with the lower part of the tunnel. The overflow rests upon solid rock at a distance of four hundred feet from the main dam and on the other side of a small hill.

The top of the dam was finished with two stone walls on either side of a roadway built with some of the boulders obtained in excavation. This makes a substantial finish to the top of the dam and also a safe arrangement for the road. The road was carried entirely around the reservoir, a distance of more than three miles, replacing in this way the various roads that were submerged and making continuous connections in all directions. The road was carried over the main outlet by a reinforced concrete arched bridge, with fifty feet span, and over the various tributary brooks by concrete arches of shorter span.

The catchment area of the Borden Brook Reservoir is about 8 square miles and the reservoir when full holds 18 inches of run-off from this area.

A record was made for speed in the construction of the Borden Brook reservoir. The contract was awarded December 16, 1908, to Coleman Bros., Boston, who were not the low bidders, but were selected by the Water Board because it was believed that they had the ability to push the work forward with great rapidity, and this belief proved, by the execution of the work, to have been well founded. Some of the heavier parts of the plant were hauled onto the work over very bad roads fourteen miles from the nearest railway station on sleds during the winter. The work was started actively in the spring, as soon as the frost was sufficiently out of the ground, and 145,000 yards of very tough material were excavated and placed in the dam, and all other work completed except minor finishing by December 1st, 1909. The tunnel outlet was closed three or four days before this and



BUILDING THE PURE WATER RESERVOIR.

thereupon the reservoir commenced to fill. Heavy precipitation through the winter filled the reservoir in less time than was anticipated, and the full overflow level was reached in April, 1910, just a year after the beginning of active construction work.

All parts of the work, the dams, reservoir, tunnel, pipes and filters, were underway at the same time. The various contracts called for the completion of the respective parts of the work in the fall of 1909. Each of the six main contracts was so far completed that it was possible to put the whole system in service about the 20th of December, 1909.

It was extremely fortunate that this was the case for the Ludlow Reservoir became very nearly empty on that date, and there would have been a serious shortage of water if the new supply had not been available at just the time that it was turned on.

Mr. Elbert E. Lochridge, as Chief Engineer of the Water Board, was in charge of the construction work, with general advice from the Consulting Engineers, who furnished all the plans and specifications.

A very efficient corps of resident and assistant engineers aided in carrying out the different parts of the work.

The estimated cost of the whole work, including the land rights and engineering and contingencies, was about $2,161,000, of which about $1,781,000 was allowed for the works herein described. It was a piece of great good fortune for the City of Springfield that most of the larger contracts were let at a time of slack business and comparatively low prices. Advantage was taken of this condition by increasing the sizes and capacities of some parts of the work above those originally estimated on, but notwithstanding these increases, which would generally have increased the cost of the work considerably, the whole of the construction work will be completed well within the estimate. In addition to this are the payments for land, for diversion of water and for right of way, originally estimated at $380,000, and the exact amount of which cannot be yet stated, because the water damages, the largest item, and some land damages, have not yet been settled.

For a sum of money not very much, if any, greater than that which would have been required to rehabilitate the Ludlow supply and filter it and put it in good order, the city has thus secured an entirely new supply of greater capacity, and giving also greater pressure, with an ample distributing reservoir nearer the city, and with rights acquired to double the supply. It also holds the old Ludlow supply in reserve, and can use it if necessary to furnish a certain amount of very good water drawn through the intermittent filter, constructed for temporary use, but capable of being kept up for use at any time that it may be needed.

CONSERVATION OF POTABLE WATERS

J. M. DIVEN

Of the brook, the beginning of all of our rivers, the poet has beautifully said:

> "For men may come and men may go,
> But I go on forever."

While appreciating the beauty of the sentiment—which reminds us of the babbling brook of our childhood—we know that the poet was wrong. For men have come, men with axes, and the brook has gone dry; and these men and their descendants, stay to pollute what is left of the once sparkling, beautiful brook. Men have come, and built towns and factories on the banks of the streams fed by the brooks—not in sparkling, constant streams, but in turbid floods—and have dumped their waste into them till the once pure streams have become little better than sewers—nauseous floods, uninviting and dangerous sources for water supplies.

Man's ingenuity has coped with man's carelessness, and many devices have been perfected for repurifying the contaminated streams. But it is an unequal fight—the scientific skill of the few against the criminal carelessness and indifference of the masses; and it seems probable that, unless soon checked, the filth producers will triumph over science and render all our streams and lakes unfit for domestic water supply. And most people "prefer innocence rather than repentance" in their water supply.

When we consider such examples as the purification of the water of Bubbly Creek, Chicago, we gain great faith in science; yet, how many of us, even with the record of the wonderful results accomplished there, would care to make daily use of such a water; from the aesthetic point of view, it would be repugnant to us. And yet, with the continuance of present tendencies, it will not be long before all of our streams and lakes are like the Bubbly Creek of today. It is high time that all those entrusted with the water supplies of the people in cities and towns commenced to take action to prevent further unnecessary contamination of the sources of their water supplies. They should not only look out for the protection of their present sources of supply, but should also consider other and more remote possible sources of supply.

Cities and towns are growing rapidly, and the demand for water even more rapidly. People are becoming educated to the plentiful, even lavish, use of water. New uses for water are constantly arising; even with the increased use of meters and other waste preventing devices, the per capita consumption in our cities is increasing. The bath tub, the lavatory and the water closet, once considered luxuries, are now looked upon as necessities, even in the homes of the very moderately well to do. These increased demands for water must be met, and at the same time, people are being educated to and are becoming more insistent upon the purity of their domestic water supply.

For a while the present sources can be made potable by filtration and by strict prevention of waste, can be made sufficient for present needs. But we should look ahead, a long way ahead, and begin even now to prepare for many years to come.

Every city not situated upon a lake or river with an almost unlimited flow—and few are so fortunately located—should at once begin to investigate and acquire other sources of supply. To do this, it may be necessary to consider sources a long way off, to consider the possibility of purifying supplies not now considered fit for use, to thoroughly investigate underground supplies, and possibly the bringing together of many scattered and diverse sources of supply.

These sources should not only be investigated and tested, but actual ownership should be acquired without delay. Such supplies are becoming more and more scarce, as their waters are appropriated for other uses or rendered unfit for domestic use, by increasing contamination.

Ownership of water rights, even of water bearing lands will become valuable assets in time, and that time is not so far off. We know now of many instances in which large sums of money are being expended for water rights, that might have been secured a decade ago for very small sums. There are many known cases in which water rights that could have been bought and held with a reasonable outlay, are not now available at any price; having been diverted to other uses or ruined by excessive contamination as a source of domestic supply.

There are some few instances of foresight in this important matter, notably the work of the Metropolitan Water Board of Boston, Massachusetts and Lake Cheesman at Denver, Colorado—a very large supply provided for the future needs of the city. But such instances of forethought and preparation for the future, are all too rare.

Every city not having an unlimited supply, ample not only for present needs, but for many generations to come—and what city can boast such an ideal condition—should make plans now for the future by securing every available source of supply within reason, either by purchase of the sources or of rights in the waters.

This may, in most cases will, entail an outlay that does not seem immediately necessary, and it will be hard indeed to impress upon the popular mind the importance of making such provisions for the future. It is something that will cost them money, money for which they cannot see anything coming back. But if the opportunities of securing good water supplies are not taken advantage of now, the future generations will be helpless, for there will be no such supplies for them to procure at any price.

In many instances lands and waters could be purchased and operated at a profit, the lands being used in such a way as to conserve and protect the waters; and the waters sold for power, irrigation or other purposes, *always reserving the right to use as much as needed for domestic use.* Such management and use of lands on water sheds and the waters should become a part of the study and work of water works engineers and officials.

Water companies as well as municipalities, should make such provisions for the future. And when they are made by the progressive up-to-date water company, the city authorities —the citizens—should be broad enough to recognize the outlay as a legitimate part of the construction of the plant; as a part of the necessary outlay for procuring and insuring to them an ample supply of water for all uses. Not only should the original investment in such lands and water rights be recognized as a proper investment and part of the cost of the water works, but the amount expended for interest, taxes and upkeep from year to year, above any income derived from the lands or waters, should be added to the construction account and have full credit in case of an appraisal of the works and in adjusting rates.

There is, of course, the danger that dishonest water companies or manipulators would make unnecessary purchases of lands or put excessive values on lands and water rights acquired, to secure a larger price for their plant or to keep up rates. But this could and should be guarded against in the franchise. But that a water company is entitled to full allowance for lands and water rights acquired, and for maintaining the same till needed, should be an established fact. Otherwise few water companies would make the investment needed to insure a city a supply for long years ahead,—years beyond the life of the franchise.

But the rights and interests of the citizens should be guarded, and provision made that they may acquire the lands and rights at their value when purchased, plus the interest on the investment, taxes paid and expenses of maintenance and protection, with some possible allowance of profit. But they should, under no circumstances be compelled to pay for lands and water rights at a largely appreciated price. Such a course would be too apt to lead to speculation in lands beyond any reasonable provision for the city's needs. It would surely be a most attractive speculation, as the investor, knowing that in time the city would have to buy his lands, paying cost, plus interest and maintenance, would be insured against loss at the start.

But proper provision can be made to guard against all such contingencies. When the lands and rights are purchased, the cost, should, by agreement, be added to the value of the company's property. To then keep track of the cost to the Company of holding them, would be a simple matter, so that when the time came for adjusting values and rates, this feature should give no trouble. As to whether a city should have the right to pass upon the question of what lands and water rights a company should acquire, is a more complex and doubtful question.

In addition to procuring water rights for future use, the question of the preservation of the purity of present and contemplated supplies should be made a part of the water works engineers and managers work. Yes, this means that they should study sewerage and sewage disposal, as well as cultivation or use of land and handling of water powers. Rather a large contract, maybe, but the providing of potable water for all city uses is getting to be a large question and more difficult each year. And it is our business to meet the situation and overcome all the difficulties.

In the securing of water privileges for future use, there is some danger that the rights of others may be overlooked, and that a municipality or water company in looking out for its own future supply, may infringe on the rights of others, by taking up supplies that they needed. A city might go so far as to take up every available supply over a large territory, preventing other communities from obtaining any supply. This would be an injustice and hardship, especially to a growing town or a new one that might be built up if a good water supply could be obtained; particularly in cases where the supply was not needed for the present supply of the town holding the lands and water rights, they having been secured for possible or probable future demands.

Yet, the securing by a municipality of a source of water supply beyond its present needs is only a reasonable precautionary measure; and the city that allows another to secure its probable source of water supply is neglecting its opportunities. A possible remedy for such an evil would be for the state or other political division to assume control of all water supplies within its limits and sell or apportion them among municipalities or water works companies.

The waters of the state could be better conserved and protected by it than by a corporation or municipality; the state could make and enforce laws prohibiting the contamination of lakes and streams within its borders, by dumping into them domestic and industrial wastes and refuse. But frequently a city derives its water supply from a neighboring state, so that the matter becomes national or even international.

And now three new dangers confront us: the development of hydroelectric plants, irrigation projects and improvement and extension of inland waterways.

HYDRO-ELECTRIC PLANTS

To the writer's mind this is the gravest danger, the one of the three mentioned above that is likely to cause us most trouble in the future; and it seems to the writer that the water supply interests would be remiss if they did not forestall these projects by securing rights in the waters sufficient for their use, not only now but for many years to come. If we do not do this, we will have, in time, to face the other side of "GOING VALUE." For when these power plants are once established and in operation the waters will have a value to them as going concerns; and this is likely to prove many times more than the supplies could be secured for before the establishment of the power plant, plus the cost of holding them in reserve until needed.

There might even be a doubt of a municipality's or water company's right to condemn the property of a going concern, with an established business of furnishing power. Thus a city or town might be rendered entirely helpless in the matter of a sufficient water supply. Let us consider the case of a city that has outgrown its present supply by reason of increase of population—due may be to cheap power supplied by hydro electric plants—and demand for water for domestic and manufacturing purposes, with all available water supplies, except its present plant, in use for power purposes by established plants, and a law protecting these plants against condemnation of their water rights or any part thereof, what could be done? Water consumption could be cut down, possibly, by measuring every drop, by stopping all leaks in mains and services, by cutting off all sprinkling privileges—leaving the streets to the dust which causes so much discomfort and danger to health, the beautiful lawns, which add so much to the attractiveness of many cities, to dry up—in fact, cutting off all uses for water except those that are absolutely necessary to life; and yet, as the city continued to grow, not enough water to supply the imperative demands, what would be the result? Would not the city have to cease to grow, and yield up its prosperity and a part of its population to more favored cities, to cities that had had forethought to provide for their future needs in water supply? And with this condition we can well imagine how those who had neglected to provide an ample water supply when it was possible, would be criticised.

With the advent of electric transmission of power, streams too remote to have been considered previously for power purposes, have been made use of, and with the rapid improvement in water power plants and appliances, others formerly considered too small to be of use, have been developed. Small streams are being concentrated in large storage reservoirs for power plants. In fact, every possible water power, no matter how remote or small, is being considered and developed. Streams, lakes and other water sources that we have looked upon with complacency as available when we needed more water, are rapidly being appropriated for power purposes and thus taken from our available future supplies. There is rumor of a gigantic TRUST that is trying to secure control of all water powers and waters for power in the country. What chance would a small town stand against such a corporation if it needed some of the water rights owned by it?

It seems to the writer that it would be only a wise precaution for municipalities and water companies to pre-empt as much as possible of the water supplies that it might need in the future; even securing possession, rights or option on large supplies, although the likelihood of needing them was very remote. They would then be in a position to dictate terms to the power companies and manipulators; and should insist upon such terms as would give them the first right to an ample supply of water for all prospective public uses when it was needed.

If, as would probably be the case, the water or water rights were leased or sold to power companies, the lease or sale should provide that the municipality or water company was to have, without excessive payment, the water that it needed. This would mean a reservation in the sale or provision in the lease entitling them to the water for their uses, and for as much as they might need.

IRRIGATION PROJECTS

These are for the most part established in sections remote from any city or town and, therefore, not a great menace to public water supplies; though the very establishing of these projects and irrigation of large tracts of land will lead to the building of towns. But as such towns have no existence before the construction of the irrigation system they have no prior rights, and must make such terms as they can for their water supplies if they cannot obtain them independent of the irrigation project—the project that gave them birth.

But, when the success of the irrigated districts, which are at present only in sections where cultivation is impossible without irrigation—becomes known, it is probable that other sections will take it up. This is more probable in the vicinity of cities, where the land can be used for truck growing, and other crops that will bring large returns. Such irrigation projects would take the water that the city might need, and would, like the hydroelectric plants, have to be dealt with as going concerns with prior rights in the waters.

IMPROVEMENT AND EXTENSION OF INLAND WATER WAYS

This is a question that is just now attracting a great deal of attention, and if the agitation bears fruit and a large number of such water ways are constructed, they will draw heavily on the upland waters of the continent. They will necessarily be in most cases lock canals, and the volume of water required for their operation will be very great. Waters that would not be available for power would be for the water ways, but if they become extensive and general, all available water in many sections will be needed for their operation. This will mean that the small streams in the high lands will be taken possession of and large storage reservoirs constructed to conserve these waters for use in dry seasons, just when a city would require its largest supply. In time of a drought, the canal systems would be loath to part with any of their stored waters even for so important purposes as domestic use and fire protection. And the cities that had not secured prior rights in these supplies would have to look further for their supplies, which might involve large outlays of money by them. They might even be restricted and hampered in their growth, for being unable to secure a water supply for a greater population, they would cease to grow.

The writer fully appreciates the importance of cheap power, increased fertility of the soil and better and cheaper transportation facilities, but considers an ample supply of water for domestic, sanitary and fire protection purposes, of infinitely greater importance. He does not begrudge the water to produce power, fertility of land and cheap transportation, but contends that none should be diverted for these uses until an ample supply is assured for public supplies. Power can be supplied in other ways, much of our soil will produce good crops without irrigation and other means of transportation are available, if not quite as cheap as canals, but we cannot live, our cities and towns cannot prosper without a good water supply for domestic use. After this is taken care of, then by all means devote what is left to power, irrigation and transportation. But none should be diverted for such purposes till an ample supply and of good quality is assured for domestic supply, and this should include a liberal supply for all sanitary purposes and for fire protection; water to drink and prepare our food with; to keep our dwellings and business places, as well as our persons, clean; to keep down disease producing dust in our cities and towns and keep our streets clean; to keep our sewers and house drains thoroughly flushed and to protect our property against fire. And no water but pure water should ever enter the water supply mains: separate systems for domestic and sanitary use, manufacturing and fire protection, would be expensive and undesirable, because there would always be danger of careless people drawing from the wrong supply for drinking or domestic use.

Until all these things are amply provided for, not only for the present, but for all time to come, not one drop of potable water, or water capable of being rendered potable, should be diverted for power, transportation or irrigation. But let us first and above all other considerations be sure of our municipal water supply.

We should get in ahead of all power, irrigation and water-way projects and schemes and acquire first option or right to water supplies available for our uses. We should have the foresight and forethought to provide for many years ahead, if not for all time. Indeed, we should adopt the precept of David Harum "Do unto others what you know they will do to you, but try to do it first."

CONCLUSION

To the writer it seems that we now have five important things to investigate, study and, as far as possible, carry out, to insure water supplies for our cities and towns in the future.

1. Preservation of existing forests.
2. Reforestation of uplands, steep hill and mountain sides and other lands that will grow trees, but are unfit for cultivation.
3. Prevention of further contamination of sources of water supply.

4. Purification, so far as possible, of streams, lakes and other sources of water supply, that are now polluted.
5. Securing prior rights over power, irrigation and water transportation projects in waters that may be needed for our supply in the future.

1. Preservation of forests: in this we will have to call in state and government aid, as it is too great a project for municipalities and corporations to undertake. Though to some extent, by purchase of nearby forest tracts they can accomplish their object.

2. Reforestation: this too, should be the work of the states or government, but suppliers of water can do something towards it by purchase and planting of cheap waste lands on their water sheds. This brings in Forestry as one of the accomplishments that we should acquire.

3. Prevention of further contamination of sources of supply: this involves questions of sewage and factory waste disposals. It also can best be regulated by the making and *enforcing* of proper laws and regulations.

4. Purification of contaminated sources of supply: this can, of course, only be accomplished by stopping the further dumping of filth into such streams, lakes, etc. and giving nature a chance to purify them. Here, again, the aid of the law must be invoked, unless the suppliers of water go into the sewage and industrial waste disposal business, paying the cost of the work. Even, then the law would have to be invoked to induce some people to allow the proper care of their waste and filth, although it was to cost them nothing.

5. Securing prior right over power, irrigation and water transportation projects in waters that may be needed for our supply in the future: this is a matter that we must take care of ourselves though we ask the enactment of laws permitting and regulating the taking up and holding the necessary lands, water rights and waters.

The business of water supply is becoming more and more complex; and the writer's object has been merely to call attention to some things that seemed to him new and of some importance, things that are generally neglected. While in some few cases action has been taken along the lines suggested, such instances are too few. One state has passed laws prohibiting the selling of any of its waters outside of its borders, but this is a doubtful provision and a little selfish. There are probably many instances in which cities procure their water supplies outside of the borders of the state in which they are situated. However, where a state has taken measures to conserve its water resources, by planting forests, building storage reservoirs and other methods, it is reasonable and right that it should have title to all such conserved supplies, with the right to restrict their sale outside of the state, except for the state's profit.

DISCUSSION

Mr. A. A. Reimer: The writer of the paper refers to the fact that one state has enacted a law forbidding the waters of that state from being diverted to another state, and he comments upon that as being a little selfish. I am glad he put in the word "little." I believe if he had left it out it would have been even better. It is selfish, but I think it is selfish along the right line, for I believe that one of the things that the various states have to do in the near future is to adopt the policy of conserving their own water supplies for their own municipalities over which they have an immediate control; and I feel that the states should be properly selfish in that very respect, for I doubt whether it is possible by any easy means to secure any national legislation that will lead to a board with control over these supplies even when they are more or less inter-state. So for the present I think that it should be the policy of the various states to conserve their own supplies in favor of their own municipalities. I know of a case of a comparatively small city that is in the immediate neighborhood of a rather large city. The smaller city is forced to put up with a very limited supply of water owing to the fact that lands in the immediate neighborhood and within ten or even twenty miles are held at high prices. The larger municipality can afford to purchase those lands, but the smaller municipality must take what is left, and is now searching for some possible supply for the future that will not be too expensive. This has been brought about by the conditions that our secretary has mentioned in his paper. Other interests have gone into that territory and have purchased rights, and often times bought the land in fee. It is only the larger corporations that are able to put out large bond issues and purchase portions of those rights. I feel that as an organization here we should throw our influence toward any legislation that will look towards the conserving of our potable water supplies. I think the secretary has sounded a true note which it is well to follow up in our home states and municipalities.

Mr. J. M. Diven: I think I went a little further than the last speaker has given me credit for, when I spoke of the selfishness of states in reserving the waters for themselves. I stated that where they did pass laws and take steps to conserve those waters that the waters certainly belonged to them; but that to deny to a city bordering on their state the right to take waters which they had taken no steps themselves to preserve the purity of or to store up, was "just a little selfish."

Mr. L. J. Le Conte (*by letter*): Preservation of existing forests is commendable from a great many points of view; but the nature of the problem is such that the national government alone could undertake it. The same remarks apply with equal force to re-forestation of uplands.

Prevention of further contamination of sources of water supply certainly calls for the closest attention. Pollution troubles always increase with population, hence the old state of Massachusetts stands at the head of the program for density of population, and for the best experience in stream pollution. Here we find the best laws and wisest councils.

Next in order, comes the old state of Ohio; where, at Columbus, we find the most elaborate and complete purification works erected and in actual operation, developing remarkable results at a very low unit price.

The remarks regarding securing prior rights over power, irrigation and canal projects, in waters that may subsequently be needed for our domestic supply in the future, seems to be very timely. These great conflicting interests should be completely under the control and regulation of the state laws; and whenever a permit is granted for a given structure to be built, it should not only be revocable, but also have a time limit in it. An extra clause, making it also contingent upon good behavior, at all times, would be a wholesome medicine.

THE COST OF FURNISHING WATER WITH REFERENCE TO RATES AND RATE MAKING

DANIEL W. MEAD

No argument is necessary to sustain the position that any investment for the public service, if conservatively and intelligently made, should be expected to result in earnings which will maintain the investment intact and guarantee from the investment a fair return. The returns should be commensurate with the risk involved, otherwise, the public cannot expect to secure service when such risks exist. Fair returns, therefore, must include:

1. Interest on the investment necessary to construct the plant and to develop the public utility into a going concern.
2. Depreciation and maintenance charges sufficient to maintain the investment intact.
3. Cost of operation, including station and distribution expenses.
4. Cost of business management including office expenses, collection charges, etc.
5. A reasonable profit in addition to the above and commensurate with the risk involved.

It is only through the prospect of such returns that the necessary funds can be secured for the construction of public utilities.

As with other investments, the returns from public utilities, especially in the smaller communities, are frequently disappointing, and the actual earnings are often less than a "fair return." On the other hand many such utilities in the larger communities are very profitable and in some cases these profits have been so great as to warrant the feeling that they were unfair to the public and should be reduced to reasonable limits.

With the question of reasonable limits comes a marked difference in opinion according to the point of view from which the matter is considered.

In considering the adjustment of rates for the services of any public utility, popular judgment is usually based, perhaps naturally, on a comparison with similar rates in other localities. Such a comparison is also frequently the sole basis of attempted rate regulation by local authorities. Where the conditions are essentially similar in the localities compared, the results may be essentially equitable, but the mere comparison of rates, without taking into consideration, in detail, the local physical conditions, may frequently lead to most unjust and unfair conclusions.

This is especially true in the adjustment of water rates, for the conditions which control the cost of services, vary so greatly with the character of water used, the treatment necessary for rendering the supply suitable for domestic and manufacturing uses, the height to which the water is to be raised. and other factors of this character, that in many cases the fair returns for one plant should be quite different from that which might be equally fair for another.

Without discussing the matter at length the writer feels assured that the basis of rate making, above set forth, is the true basis on which an equitable adjustment of such matters must be made. In arriving at the findings on this basis, much difference will result, for estimates of valuation, depreciation, maintenance, etc., can by no means be made exact.

As illustrating the effect of varying conditions on the necessary cost of service and the necessary variations in rates due to such conditions, and as further illustrating the injustice of the attempt often made to reduce rates without due consideration of the above principles, the following data is offered concerning a case which was under litigation in the City of Chicago in 1904-5. About 1904 the City of Chicago extended its limits taking in certain territory which received its water service from a private water company.

Some of the citizens of the new ward objected to paying rates charged by the water company, and an ordinance was passed by the Chicago City Council reducing the rates of the water company in the new ward to the rates charged by the city for similar services in adjacent territory. The company resisted this change in rates, and the following report was submitted and formed the basis on which the case was presented:

"In the matter of the estimate of the "fair return" or equitable income which the water works plant of the ———Suburban Water Company at———should earn, I wish to call your attention to the following facts:

The City of Chicago has attempted to force this Company to reduce its rates in———, which is now within the limits of Chicago, to those charged by the City of Chicago itself. The inequity of this will be seen by all who examine into the different conditions under which the two plants are operated, and who recognize the fact that the expense of operation, and the consequent necessary "fair return" depends almost entirely on such conditions.

The following parallel comparison of the plants owned and operated by the City of Chicago and by the ———Suburban Water Company will serve to illustrate these differences. The latest data for the Chicago Water Works is for 1901. I, therefore, compare it with the Suburban works for the year ending July 31st, 1902, with which such data most nearly corresponds in time.

Comparison of Water Works.

	PRIVATE WATERWORKS 1901-2	CHICAGO WATERWORKS 1901
Estimated value of works..........	$600,000	$34,000,000
Population served................	25,000	2,000,000
Investment per capita............	$24.00	$17.00
Miles of mains....................	62.50	1890
Consumers........................	4096	227,300
Consumers per mile..............	65.5	120.0
Mains per consumer...............	80.8 feet	44.0
Source of supply..................	Artesian Wells	Lake Michigan
Sanitary character...............	Unquestionably good	Suspicious
Height raised by pumping........	225 feet	106 feet
Annual pumpage in million gallons..........................	370.4	125,130.5
Average daily pumpage in million gallons.......................	1.05	342.83
Annual income from works........	$62,234	$3,397,928
Actual operating expenses........	$34,249	$1,138,392
Depreciation 1% on valuation....	4,800	300,000
6% Interest on valuation.........	36,000	2,040,000
Total annual expenses.......	$75,049	$3,478,392
Net loss per annum..............	$12,815	$80,464
Cost of pumping 1000 gallons.....	22.82 cents	2.79 cents
Income per 1000 gallons..........	16.76 cents	2.76 cents
Actual loss per 1000 gallons pumped......................	6.06 cents	.03 cent
Cost of operation expenses per 1000 gallons.................	10.8 cents	.91 cents
Cost of operation per consumer....	$9.15	$5.00

The above comparison needs little comment. It might be considered equitable when a Water Works can pump water at 3 cents per 1000 gallons, to place the minimum meter rate at 10 cents per 1000 gallons, but it should be noted that when interest and depreciation are considered the City of Chicago itself, does not receive a fair return on this basis, but receives only 2.75 cents per 1000 gallons, and sustains an actual loss of .03 cents per 1000 gallons pumped. Thus it is seen that Chicago itself, in order to receive a fair return on the cost of operation and investment, should raise its rates above those now charged. Such losses should be anticipated, and are due to leakage, wastage and to free water which is furnished to some extent by all plants.

The greater cost of pumping smaller quantities of water under higher heads is also well shown by this comparison. That this is not peculiar to this suburban plant, but is the necessary consequence of the conditions, is known to every water works engineer.

The City of Chicago in some of it smaller works furnishes good samples of this fact. Take, for example, Washington Heights. At these works the station expenses were as follows:

	OPERATING EXPENSES	REPAIRS	TOTAL STATION EXPENSES	TOTAL 1000 GALS. PUMPED	COST PER 1000 GALS. ON STATION EXPENSES
1900	7263.68	844.07	8107.75	118,195	5.85
1901	8715.18	1262.73	10477.91	139,176	7.47
1902	6555.50	2354.65	8910.15	156,954	5.68
1903	8485.56	747.69	9233.25	243,565	3.79

At Norwood Park, the works also operated by the City of Chicago show expense as follows:

	OPERATING EXPENSES	REPAIRS	TOTAL STATION EXPENSES	TOTAL 1000 GALS PUMPED	COST PER 1000 GALS. ON STATION EXPENSES
1900	4948.52	138.03	5086.55	30,200	16.88
1901	5098.51	376.22	5474.73	28,380	19.35
1902	4342.37	736.90	5079.27	28,195	20.55
1903	4170.78	200.18	4370.96	26,356	16.59

These figures include only station expenses. If to these were added cost of supervision, general repairs, collections, deterioration and interest on the investment, it is obvious that the cost would in every case, be increased from 20 to 40 cents per 1000 gallons.

It should also be noted that at Washington Heights the head pumped against is 109 feet, or less than one half of the head at——. The head pumped against at Norwood Park is unknown to me. The charges the city is making for water in these suburbs could only be sustained by a general tax or by making the other water takers of the city pay for the yearly loss thus incurred.

The details of the cost of operation of the ——— Water Works for the last three years is shown in the following table:

Annual Operating Expenses:

	1902	1903	1904
Fuel	$10,180	$11,700	$12,500
Taxes	5,031	3,756	2,780
Insurance	457	16	127
Legal expenses	600	1,826	1,401
Supplies	1,331	1,297	1,514
Repairs	3,522	3,575	3,135
Printing	203	288	175
Telephone	61	70	91
Oil and waste	732	610	670
Cartage	626	500	680
Miscellaneous expenses	750	585	658
Envelopes	158	106	159
Labor	10,598	11,451	11,605
Total	$34,249	$35,720	$35,495
Interest on value of work	36,000	36,000	36,000
Depreciation (1% of $480,000)	4,800	4,800	4,800
	$75,048	$76,320	$76,295
Total quantity	62,235	70,741	76,815
M. Gallons pumped	370,300	391,000	454,800
Cost per M. gallons based on operating expenses	9.17	9.10	7.78
Cost per M. gallons based on total cost	20.30	18.60	17.80
Gross Income per M. gallons	16.76	18.10	17.85

The foregoing table shows that the Suburban Water Company had been operated at a loss at their established rates, and that any reduction would be inequitable.

The court so held. The matter was afterwards adjusted by the City of Chicago purchasing the distributing system within the city limits, which they then connected with the city system.

DISCUSSION.

Mr. Edmond T. Sykes: In the case of a municipal plant I think the tax question should be considered, and also that a reasonable value should be allowed for the unpaid water.

MR. A. PRESCOTT FOLWELL: In making a comparison between municipal and private plants, it is not fair to compare a municipal rate with a private rate. The United States census covering municipalities of thirty and forty thousand population in this country is based very largely on a method of accounting, which is quite comparable to the one that is proposed in the proceedings here; and on the basis of such a method of accounting they found that only twelve municipal plants out of the one hundred and thirty odd in cities of over thirty thousand population are actually making a profit as determined by that system of accounting. The others were all losing money. To endeavor to make a comparison of the rates of private companies with the rates of municipal plants certainly would be inequitable.

MR. EDMUND T. SYKES: I have heard the statement made that our water plant in Minneapolis was making money, but that is denied by the accountants who are investigating the matter at the present time.

MR. STUART WOOD: A water works perhaps differs from any other industry in the fact that the proportion of capital employed to the operating expenses is greater. I presume that there is no other large industry where approximately as much as one-half, even in many cases more than one-half of the cost of furnishing the commodity is due to the cost and depreciation of the plant, as is the case with water works. Private water works companies of course are compelled to take this into consideration in establishing their costs; but that is not always the case with municipalities, and the accounts of the latter are not kept with the same objects in view. As a result I think it will be found that very often municipal operating costs are published which are made up simply of operating expenses, wages, fuel, and ordinary repairs. I have in mind one city which feels very well satisfied that it is making a profit on its water works, where they charge to cost of operation, interest on a little more than $1,000,000 of bonds, while the value of the works they claim to be about $10,000,000. Now, of course, published rates based upon such figures as that are very misleading if they are supposed to cover the actual cost of furnishing water; and to compare such rates with those of neighboring cities is very unjust. But such a practice is very often prevalent, and I think in consideration of this fact it should impress upon our minds the very great importance of a uniform accounting which will apply to municipal as well as private plants. Such in fact is the purpose of the present legislation in Wisconsin; I think that any legislation for the benefit of water works ought in fairness to enforce that practice on municipal and private plants alike.

MR. W. F. WILCOX: I hardly agree with what Mr. Wood has said. The reason why a great many municipalities say that they pump water for a certain figure is because their books do not show thoroughly every item of cost. I represent a municipal plant, yet I was raised a corporation man. I have had this to contend with in the management of a municipal plant, that the politicians want to show the people how little they are charging and how little it costs them to do the work. It is not fair to say that depreciation and similar items cost you nothing, it is simply a political game. The municipal superintendent therefore finds himself in an attitude antagonistic to the politicians whenever he attempts to state the true cost of pumpage.

I think that Mr. Wood's suggestion as to uniform accounts is a very timely and proper one. In our city we charge for everything the city gets from us, and we credit the city for everything we get from them. If we have the city engineer run lines for us we pay the engineering department. If we have the board of public works repair a street, we pay them. If they get any water from us they pay us. We do not carry any fictitious charge on our books as to what the city owes us for water; but in fixing our rate we adopt what would be a reasonable charge if a private corporation owned the plant. We also take into consideration the taxes that a corporation would pay to the city. Deducting these taxes from what is a fair charge by the corporation leaves what we charge to the general city government, and we collect that every year in cash.

Our plant supplies 30 000 people. Our total pumping cost at the station is $20.40 per million gallons, including filtration. Our water flows by gravity during a portion of the year; but in the dry season we have to double pump water from the impounding reservoir; that carries up our cost a little. We figure the actual cost of operation, the interest on the bonds, and the depreciation charge. As to the latter we have introduced politics for the politicians. We computed the depreciation as nearly as we could, and arranged that that amount of our city bonds would come due every year. We pay off that portion of the bond issue every year to take care of the depreciation.

Mr. T. C. Phillips: I might explain the situation at Washington Heights, one of the small suburban pumping stations of the city of Chicago, which is located about nine or ten miles inland from the 68th street pumping station. The water supply for this pumping station is taken from a sixteen inch pipe line leading from the 68th Street station four or five miles in length. This sixteen inch line is also used as a service pipe line for a small suburb of the city through which it passes. The Washington Heights pumping station pumps against sixty pounds pressure. We found last year that at times we were not able to maintain sixty pounds pressure on account of the large amount of air in the supply line. The origin of the presence of air is attributed to several causes. The results of it, however, caused the pumps to run faster to maintain the pressure. The slippage of these pumps was measured with a pitometer, but the percentage of the same was not accurately obtained on account of the variation in the volume of air in the supply main. I make this statement to show that the amount of water assumed to be pumped (as shown by the pump recorders) at this station during the past, is not reliable, and any estimate of the cost of supply based upon the pump recorders' record is therefore erroneous and probably too low.

The figures from which Mr. Mead made his deductions were compiled for the years 1901 and 1902, I believe, and during those years the same conditions existed, to the best of my judgment, as those of last year.

The total ordinary expense for pumping water for the City of Chicago is about three cents per 1000 gallons. Perhaps it would be well to explain that this does not include any item for sinking fund, depreciation, or interest on cost, it includes total ordinary expenses only. The large expenditures incurred for purification of the water are not taken into consideration at all in this estimate of the cost of supply.

With regard to the question of rates in the city of Chicago, I believe that those in vogue at present are too low, for the reason that a large portion of our supply is unaccounted for, and the actual cost therefore would be a figure possibly near our present meter rates, *viz:* seven cents per 1000 gallons.

Mr. John W. Alvord: If anybody would casually mention inside of the city limits of Chicago that our Chicago water works was not making money, well, I would not like to guarantee what might happen to him. The general impression is strong that our Chicago water plant is a great money winner. As Mr. Phillips has pointed out, for a number of years large portions of the money from the water fund has been used for miscellaneous purposes connected with the preventive of pollution and the maintenance of the purity of the supply; for instance, the construction of large conduits which are really sewage conduits and have no connection with the water system, but which are merely a protection to it in keeping the sewage out of it. The real cost of water in Chicago is a very interesting question, which I have wanted to have investigated for a long time. Do I understand, Mr. Phillips, that in this three cents the interest and the cost of depreciation is included?

Mr. T. C. Phillips: No Sir.

Mr. J. W. Alvord: I understand it is not included. That is where the cost given is misleading. The distribution system of the Chicago Water Works is largely constructed by special assessments. Having once built this distribution system through special assessment no further account is kept of the capital cost. As Mr. Wood has very well pointed out, the capital cost of furnishing and distribution water, with its fixed charges is one of the greatest items to be accounted for. Of course, not having to account for this large item, Chicago together with other cities similarly situated finds that its revenues are such that they can reduce proper rates and still have money to spend at times for construction purposes.

The fact has been mentioned that many municipal reports are unreliable, perhaps not intentionally so, but never the less so because of the ignorance of the municipal officers of the true principles and methods by which all these capital accounts with their fixed charges should be treated for operative purposes. In municipal reports such as have come under my observation for many years there is also another curious psychological feature—if I may be allowed to term it such—that is, the desire of every official to make a better showing than his predecessor. This is a very insidious temptation, and while it does not always involve anything like falsification, it very often involves carelessness of statement in explaining thoroughly the matters involved. For instance, it was my lot at one time to examine the municipal water works expenditure over a period of forty years in one of the larger cities of our central west. Each annual report of the superintendent of that plant charged up a certain amount for coal to his engines for pumping; and it was remarkable how year by year each superintendent managed to pump water for a little bit less a year than his predecessor had done and especially after each change in superintendent there was a remarkable saving for the next year. But fortunately, vouchers for the purchase of the coal were also in existence and were of possible utilization; and after comparing these carefully from year to year it was seen that there was a considerable amount of coal which had apparently entirely disappeared. I took a great interest in thus securing data for the actual account, and computing it year by year; and adding it to an imaginary coal pile I found that during the forty years operation the amount of unaccounted coal produced a pile that would cover a good sized city block over three hundred and thirty feet high.

Mr. Chas. B. Burdick: It is customary in making comparisons of the cost of furnishing water to base the comparison upon the cost per 1000 gallons. That seems to be a good basis of comparison. It is true that the majority of our water systems are not metered, and therefore the only place where the water can be measured is at the pump. It is also true that there is a very large discrepancy in every water works plant between the amount of water which leaves the main station and the amount which reaches the consumer. There are comparatively few of our plants where all consumers are metered; and it has been found even in plants that are well regulated that all the way from twenty-five per cent to sixty per cent of the water pumped never reaches the consumer at all. Therefore, one important proposition in comparing rates for water on the basis of 1000 gallons is to consider the percentage of loss of water in the mains and services. If the cost of water is based upon station pumpage the error of making a comparison of that cost with the cost per 1000 gallons supplied to the consumer is evident.

Mr. W. F. Wilcox: I want to call attention to one point: Municipalities in the south borrow money from one per cent to one and one-half per cent below what their private corporate competitors do. That is one of the unfortunate things that the private plants have to contend with. I believe I am right in stating that the majority of the private companies pay 6 per cent. We pay 4½ per cent; so you can see that we have a practical advantage of 25 per cent in the item of interest.

Mr. Leslie C. Smith: In the discussion of this matter of the cost of furnishing water I cannot but believe that a vital part of it must hinge upon the cost under varying conditions. The cost of supply widely differs in different plants. But the matter of pumpage ought to be a common basis of comparison in all plants. So that, following the remarks of a previous speaker, it is not the cost of the water delivered that offers a correct basis of comparison between one city and another, but it is whether or not each individual department that has to do with the furnishing of this water will compare favorably with a like department in another plant. For instance, from the time the pumps take the water until that water enters the main we may call that the pumpage, and that will include labor, fuel, oil, waste, etc. These charges ought to be subject and amenable to comparison in every plant.

Now if the matter of purification enters into it, that is another sub-division. If that added to the cost is to be taken as a comparative basis for another city, whether it be in softening, purification or whatsoever else, right there the figures must diverge and are unfair. So must the question of supply be considered. I find the only helpful part of any comparison is in being able to select the things that apply to my own individual situation as compared with like conditions in another city, to see if I am producing and pumping as much water, and if I am supplying and delivering as much water at the same cost as another city is doing. If not, then there arises the question of an improvement in some particular.

Mr. S. J. Rosamond: If in our city we are pumping 150,000,000 gallons of water every twenty-four hours, and in another city they are only pumping from three million to five million gallons every twenty-four hours, the latter would certainly present different conditions. Then too if there is a different head to pump against that must make a difference. I cannot see how you can draw a fair comparison simply on rate figures alone without taking into consideration all the conditions under which a plant is operated, the class of machinery that is used and what is necessary for that plant to meet those conditions, and all those various details that are included in the pumping stations under which the companies compared are operated. I have been up against this comparison business since 1905. It has caused me a great deal of trouble. I have had some of our alderman quote rates from some other city where the department takes no account of taxes and probably has no bonds out and has its plant paid for, and are taking no account of capital investment, the only accounting being bare cost of fuel and salaries, which of course does not furnish a fair basis of comparison. I cannot see that such a basis could be used except by taking into consideration the difference in cost per 1000 gallons for delivering water at the tap, and in ascertaining the cost of the property investment, as well as all other proper items of cost.

Mr. Dabney H. Maury: Mr. Chairman, it seems to me that the whole question of comparison of rates ought to be viewed from two points of view. I think it ought to be admitted that if we are considering the rates in any one location those rates should be based upon the cost, and should be so apportioned to the various kinds of sevices—such as public and private fire protection and the individual consumers—that there should be no free water to any one, but that each of these three classes, and as nearly as possible each consumer in each of these three classes, should pay his just quota of the fairly distributed charges, no more, no less. A water department ought not to make a profit on one at the expense of the other.

That ought, I think, to constitute a basis for fair rates. It follows from that, that as the conditions vary in all plants it is absolutely necessary to consider all of the conditions involved in any specific case before you can decide what ought to be a fair rate.

When you come to compare one plant with another, which is the second point of view for consideration in the question of rates, it seems to me equally indisputable that you consider the service which is furnished for the rates as well as the conditions by which the supply is surrounded. The basic question which was put up for solution in the National Civic Federation investigation of municipal ownership and operation was the cost to the consumer of a "comparable unit of service." Now a great many things enter into what constitutes a comparable unit of service. Sometimes everything is included in a rate. Very often that is not the case. Consumers in one city may sometimes even pay treble the amount of the existing rate, in order to obtain a service which is fully covered by an equal water rate in some other city.

If a plant be built by a special assessment, that does not appear in the water rate. If a plant be municipally owned and does not pay taxes, that does not appear as against the cost of production and is therefore not included in the water rate. If there be deficient protection against fire by reason of lack of pressure, that means extra appropriations for the fire department and extra insurance premiums; but these do not appear in the water rate. If the water be impure, and by reason of fear of disease large amounts of bottled water have to be bought by the community, or even other liquids have to be consumed, that does not appear in the water rate. If the pressure is insufficient to furnish the upper stories of houses with the desired supply, with the result that increased pumping is required by separate plants which have to be put in in the most expensive manner in small installations on owners' premises, and operated therefore at very large expense, that does not appear in the water rate. So that really when you get down to a final analysis and endeavor to compare what is being done in one city with what is being done in another, you have to take all these things into consideration, or otherwise you may be led into an unfair comparison.

Mr. J. D. Barnett: There is one point in this matter that has not been alluded to so far, namely, how long should your bonds run in order to be absolutely equitable? Is thirty years an equitable time, in view of not only the physical deterioration of the plant, but the functional deterioration that is steadily going on? I believe that the thirty years period is wrong, so that in the last report to the citizens I said that in the future, our board in recommending the issue of further bonds for extensions, meter equipment, and such things, would not ask for bonds of any longer than a fifteen year period.

Mr. Dow R. Gwinn: Personally I feel under obligations to Mr. Mead for having prepared this excellent paper which has brought out this discussion this morning. I was especially interested in the points made by Mr. Maury with reference to the question of service. I had occasion last summer to visit an eastern city where they furnish water to the metered customers at a rate of five cents per 1000 gallons. That rate is frequently quoted to private companies as an argument to them to furnish water at the same price. I asked a friend in that city about his water rate. He told me it was very cheap indeed, very low. I said, "What about your drinking water?" He told me how much they had to buy and it figured up to $3.00 a month or $36.00 a year. I asked him if it would not be cheaper if he paid a higher rate and got a better quality of water and was relieved of buying drinking water outside.

I am glad to see a growing disposition on the part of the courts to take into consideration differences arising from locality and their different conditions in the cost of producing service. The legislatures are looking at it also in that light, and it is time that they did. But in Kansas the legislature recently passed a law which provided that the city commissioners, where the government was under the commission form, can fix the water rates, and giving them full power to fix the rates to be charged by a company not only to the citizens but to the city as well for fire protection; but they are not allowed to make those rates lower than such as to enable the company to earn 10 per cent on its investment after paying operating expenses, cost of maintenance, taxes, etc., which I think is very fair indeed. It allows for cost and also for maintenance. That seems to be one of the fairest laws that has been passed for some time.

Mr. A. H. Wehr: It was such considerations as have been mentioned which the Committee on Uniform Reports and Accounts have had in mind, and which emphasized the importance of the work which has been begun by the committee. The various points which have been raised in this discussion have all been carefully considered by us and also by the census bureau at Washington, in the attempt to arrive at some scheme of accounts which would make it possible to present for consideration all the various factors entering into the service of water supply in connection with a comparison of rates. I have in mind one matter that has always struck me as very wrong and unjust, namely, the water rates charged by the municipal department of the city of Baltimore. My company operates immediately on the outskirts of Baltimore, and a comparison is often made between the city rates and our own. After going through the old records for as much as twenty-five years back in searching through the city archives I found the extraordinary fact that a resolution had been adopted upon the recommendation of the then mayor of Baltimore, that in order to encourage the introduction of manufacturers into the city large factories and consumers of water should be given an especially low rate; and in accordance with the recommendation the Baltimore city council passed an ordinance directing the water board to install metered services for manufacturers and other large consumers of water; and instead of giving them the flat rate charge they were given the very low price of six cents per 1000 gallons, and that price is what they are charged today, whereas other consumers are now charged a less rate. Under the schedule rates to domestic consumers the average rate paid in Baltimore by them is less than four cents per 1000 gallons, whereas manufacturers to whom it was originally intentioned to give an exceptionally low rate, to encourage them to come to Baltimore, are paying six cents per 1000 gallons. No one seems to know the difference; no one stops to inquire why that condition exists, and it is apparently not observed except by those of us who are interested in the proposition as water works men. When we began to analyse the figures we found that the only charge that is made based upon the cost of water is to cover coal expenses, the operating department and the interest on the bonded indebtedness. No depreciation charge has ever been made. A sinking fund is provided by direct taxes, and every year or two there is a special appropriation in the budget to cover the deficit in the various departments. That is a condition I think that is rather unusual. It occurred to me as a member of this Committee that that city should be informed that there is no department or company that is fixing its rates to-day upon the proper basis. We know the amount of work that has been done in connection with the fixing of gas rates and electric light rates. We have heard of a sliding scale, the Boston sliding rate, the Dougherty rate, and a number of other rates in connection with gas and electric light. It was impossible for us to embody all the various schemes of rate making and apply them to water rates fully. Before one could do that the conditions must be substantially the same in all plants. The biggest capital investment should be considered, also the capacity of your plant and whether that capacity is used in full or only in part; and the rate to my mind should be divided at least into two factors, one being fixed, representing the approximate demand, and the other being variable, representing and embodying the consumption and the customer cost. The demand cost is that cost which is fixed, based and predicated entirely upon the capacity of the system; consumption cost is that cost which varies with the quantity of water consumed. The customer cost depends upon the number of customers, and runs up by jumps. As your customers increase several thousand you have to increase your force, and the customer cost increases accordingly.

It has occurred to me that the proper method, or one that might be tried until found wanting, would be a fixed flat rate based upon the number of feet of the distribution system which is occupied by the premises of each and every consumer. This is fixed without regard to the quantity of water in use. When a flat rate covering these costs is once established you will find that the meter rate covering consumption cost will be very low. In that way a low rate is automatically applied to the large consumer of water, and a relatively higher rate to the smaller consumer.

The entire question of rate making, it seems to me must have some basis of this character in order to be just to yourself and absolutely and fairly give you a proper comparative basis as between municipalities and private plants without regard to their location, but having regard only to the conditions under which they operate and to the variable service they furnish.

Mr. A. A. Reimer: It seems to me a great deal has been said about the weakness of the municipal ownership system, and I think that it deserves a little word of commendation. In our plant in East Orange we still hear rumblings of comparisons between the old rates established by the private water company from which the city purchased and the present rates. Fortunately for us those rumblings are becoming less and less numerous, for we have given every one a chance to investigate to the fullest extent the department management, the financial system in use, the system of revenue, etc., and there seems to be general contentment now.

We account for everything, or try at any rate to account for every department in our water supply system. We account for the interest on the bonds; we account for the sinking fund. We pay it all ourselves, we get no help whatever from the municipality for fire protection, for water furnished to the various public buildings, for any service rendered to the municipal department. Therefore, in order to show the citizens what I believe to be the fair condition of the department, each year we make an estimate of the cost to the plant as it stands at the end of the year, allowing for what would be the amount of taxes if it were a private plant based on the full city rate assessed against any private consumer on his property; we charge that off. Then we take credit for water supplied to the city, at no time exceeding the rate charged to the largest consumers; so that the city gets the full benefit of everything that we give to them, and we take as much benefit as we can fairly take under that statement. The question of fire protection has been thoroughly threshed out, because the system is right up to the mark on fire protection, there are no weak points in it at all; and I feel that the rates that are established now—which have just been revised I might add so far as meter charges are concerned—represent the lowest working point that we can adopt for the time being. We have just made a reduction of 14 per cent on the meter charges.

Now, I mentioned this simply to show that a municipal plant can take account of everything and still show a profit at the end of the year. We have trouble in keeping out of the hands of the sinking fund commissioners, for under the law we have to give them all the profit that stands on the books; and we have to find all sorts of ways to keep that out of the hands of the sinking fund commissioners so as to provide for a possible contingency in the future. The state law of New Jersey, as we are informed by our state attorney, forbids our making a cash charge and collecting actual cash for any service rendered the city. For that reason we have to make an assessment charge which we do not report as an actual cash item, but simply show as an addendum to our financial report, in order to give the public the correct idea of what the department stands for in its expenses. Our flat rates are 10 per cent lower than those charged by the old private company and the meter rates are about 40 per cent less than those charged by the private company formerly; yet as I say we show a profit after accounting for everything.

A CO-OPERATIVE WATER WORKS FRANCHISE

JOHN W. ALVORD

The relations between public utility companies and the municipality are, and have been, the cause of much friction and complaint. On the one hand, it has been too much the habit of mind of owners of utilities to consider their franchise rights private property, to be used for private benefit, and to disregard the obvious interest of the public where it conflicts with such private interest. On the other hand, the public has not been fair or just in many instances to the owners of utilities, being usually convinced, and often erroneously so, that such owners were making enormous profits on slender investments. These causes have too often operated on the one hand, in causing owners to disregard their obligations as to proper purity of supply and adequate fire pressure, and, on the other hand, city authorities have often endeavored to actually proceed in such a manner as to greatly depreciate and even at times entirely ruin the value of a public utility property for the obvious purpose of purchasing it cheaply, or obtaining rates below actual fair cost.

It has long been recognized that there is a proper middle ground between these two extremes on which both parties to such contracts ought to meet, and which would be just and fair to both interests.

The tendency of the courts of late years has been more and more clearly to point out first of all that a public utility is of necessity under the obligation, to properly conserve, as a public trust the public service as the purpose for which it was created, and, secondly, that moneys invested in such utilities should be properly protected and provided with an adequate and fair return, suitable in each case to the local or general hazards and uncertainties to which it may be subject.

That the public is, and ought to be, a silent partner in the Utility Company is now recognized, and it is an open question if the time has not already arrived when it should not be more than a silent partner. Certainly in new contracts and franchises the question of the municipality becoming an active partner is being seriously considered.

In the Chicago street railway settlement this question has already been well and satisfactorily settled. The city has had a valuation made of the property, and all proper expenses of operation, maintenance, taxation, and depreciation have been provided for as well as interest on the capital invested. Over and above this the city receives 55 per cent of the net profits, if any there be. New capital is invested in the properties under the direction of a board of three traction experts, one of whom is appointed by the city and one by the company, both having an equal voice in the selection of the third. Such capital is added to the original valuation and receives its proper return, as is the case with the original investment. The city has the right to purchase the entire property at the price found to be invested on the face of the books at stated periods. Its percentage of profits may be invested as a sinking fund for this purpose, and, through its representation in the Board of Control, it has a voice in the nature and extent of new investment, and is a check against extravagant or improper expenditure.

It has seemed possible that some such arrangement as this could profitably be introduced into water franchises, and in the city of Lake Forest, Illinois, there was proposed, such an ordinance, which was carefully thought out and its effect under various conditions fully discussed by the writer and others representing the water company and the city. The results which are of more than ordinary interest are embodied in the amended ordinance submitted herewith, which contains all the features which are novel to this plan.

Briefly, the advantages to the city are as follows:

1. Beginning with an appraisal of the present property the city, by its observation of the accounts showing new capital invested from time to time is enabled to know the value of the plant at any optional period of purchase.
2. The city, may by proper adjustment of rates, provide a sinking fund (not burdensome) which at the end or the franchise period will enable the city to own the plant without further payment. In other words, the plant will be paying for itself as it goes along.

3. The city can control extension in such manner as to suit the wants of the public, being limited only by the fact that useless and unprofitable extensions are a hamper upon its own investment in the ultimate purchase or in the rates to be maintained.
4. The city can be assured that the company is not receiving more than a reasonable and fair return, and if at any time, through its neglect to revise the rates, more than a fair return is yielded, then it will receive its share thereof.
5. The city, if it desires to purchase before the expiration of the franchise, will have to its credit the sinking fund for purchase so far as it shall have accumulated at the date elected, and will be required to provide in addition, only the difference between the amount of such sinking fund and the total value as shown by the balance of account on the books.
6. By means provided in the ordinance the city will have assurance at all times as to the accuracy of the accounts and the propriety of the expenditure.

The advantages to the water company are:

1. The assurance that the capital invested will be returned to it intact.
2. The assurance that it will receive proper interest on the capital invested during its use, and a proper profit assured when all contingencies are taken into consideration.
3. The assurance that friction with the city will be avoided, and moneys can be raised safely and economically for extensions and betterments.
4. The increased value of its securities due to these safeguards.

The Lake Forest ordinance as originally granted was of the usual type, and the following proposed amendments are all that are of general interest:

An Ordinance Amending Certain Sections and Repealing Certain Sections of an Ordinance entitled:

An ordinance to provide for a supply of water to the city of Lake Forest, Illinois, and its inhabitants, contracting with the Lake Forest Water Company, their successors and assigns, for a supply of water for public and private use, and giving the said city of Lake Forest, Illinois, an option to purchase the said works. Be it ordained, etc.

Section 1. That sections numbered six, seven, and eleven of said ordinance be and the same are hereby repealed.

SEC. 2. That wherever in this ordinance the word "city" occurs, the same means and shall be held and construed to mean the city of Lake Forest, and wherever the word "company" occurs, said word means and shall be held and construed to mean the Lake Forest Water Company; wherever the word "capital" or "capital account" occurs, the same means and shall be held and construed to mean the valuation of the property, plant and system, and all the rights, present and future, of said Lake Forest Water Company at the time of taking effect of this ordinance and from time to time at all times hereafter upon the basis and under the principles herein laid down for ascertaining the same so long as this ordinance remains in force. "Operation" and "maintenance" mean and shall be held and construed to mean the ordinary, usual, and reasonable expenses of the operation and maintenance of said property, plant, and system of said company, including the ordinary and usual repairs thereto, taxes, insurance premiums, renewals, and making good ordinary and light accidents and casualties. "Replacements and renewals" mean and shall be held and construed to mean such renewals as are required to make good and maintain said plant and system substantially as the same now exists, and to do whatever may be necessary to perform and maintain the standard of service required of said company under said ordinance, approved December 9, 1890. "Extensions and additions" mean and shall be held and construed to mean any substantial extensions to the system of pipes for the distribution of water and additions to the machinery and appliances for the supplying of water, including intakes and filters, the effect and intent of which is substantially to increase or enlarge the amount or quality of service maintained or to be maintained by the company. The "income" of the company shall mean and shall be held and construed to mean the gross amount paid for the public and private supply of water by said city or by private consumers to said company.

SEC. 3. Said company, by the acceptance of this ordinance shall and does grant to said city, and said city hereby reserves to itself the right, upon giving at least six months notice, in writing, of its intention so to do, to purchase and take over the entire water works system of the company within said city, including all property then existing and used in connection with the operation and maintenance of said water works system. In case the said city shall purchase and take over the said water works system of the company, as in this ordinance provided, then it shall pay for the same the present valuation of said works as hereinafter provided, called capital or capital account, together with such additions, if any, to said capital account as may have been made hereafter and prior to the time of such purchase under and in accordance with the provisions of this ordinance.

SEC. 4. The value of said property and water works and system (define) shall be ascertained and fixed as of the date of January

1, 1908. by three disinterested hydraulic engineers, to be selected and appointed by the city and by the company by mutual agreement, and *no one of whom shall be considered nor shall be the* repre sentatives of the interests either of said city or of said company.

Such valuation shall cover and include all physical property of the company which is used or intended to be used in the business of water supply in which said company is engaged, valued as a going concern. Two copies of said valuation so to be made and fixed shall be signed by each member of said board of engineers, and one copy shall be delivered to said city and placed on file with the city clerk, and one copy shall be delivered to said company and thereupon said valuations, so made, shall become and be binding and conclusive upon said city and upon said company. Said board of engineers shall also in like manner ascertain and fix the rates to be paid to said company for water for public and private use.

Said city may determine and fix as near as may be, what fractional portion of said income of said company shall be paid for public and what portion shall be paid for private use of water and, until otherwise ordered by the said city, approximately (one third) of said gross income shall be paid for and derived from the public use of water, and approximately (two-thirds) shall be paid for and derived from the private use of water. Such rates shall be fixed so as to cover and include the following amounts and charges, to wit:

1. Operation and maintenance as above defined.

2. The establishment of a fund or surplus sufficient in amount to cover and pay for all necessary replacements and renewals from time to time while this ordinance shall remain in force.

3. The payment of semi-annual interest to said company equal in amount to(as agreed) per cent per annum upon the capital or valuation so ascertained and fixed as above set forth, with additions thereto, if any, made in accordance with the provisions of this ordinance.

4. The establishment of a sinking fund sufficient in amount to equal and cover said valuation of capital with additions thereto, if any, at the end of the period of thirty years from the first day of January, 1908, to be made up by the payment and setting apart of annual amounts out of the said income of said company, which when paid with interest thereon, compounded annually, at the rate of three per cent per annum, be equal to said capital so fixed.

In case the rates so fixed and determined shall produce in any year or term of years an amount substantially greater than sufficient to meet and cover the above four requirements as may be from time to time necessary under the provisions for addition, hereto, if any, in this ordinance contained, then such excess shall be divided and paid one-half thereof to said city, for its own use and benefit, and one-half thereof to said company for its own use and benefit, provided, however, that if said city shall so elect the entire amount of such excess may be paid to said company for its own use and benefit and a like amount shall thereupon be deducted from the capital of the said company, and a proportionate deduction shall thereafter be made upon said capital, either of principal or interest.

In the event and whenever replacements and renewals shall become necessary in and to said plant and equipment, the necessary cost and expenses thereof shall be paid out of the replacement and renewal fund above provided for. In the event that the amount in such fund shall not be great enough to cover and pay such cost and expense when the same may be incurred, then said company shall advance said deficiency, which amount, so advanced, together with the interest thereon at 6 per cent per annum, until paid, shall be repaid out of the said fund to said company.

Either party may give sixty days notice to the other to have rates revised and determined, but not oftener than once in any one year. Said notice shall be given in writing addressed to the proper officers of the said company, and thereupon a board of three hydraulic engineers shall be appointed in like manner to perform the same duties in ascertaining and fixing the rates for water for public and private use thereafter to be charged and paid as is hereinbefore provided in section four hereof.

The rates so fixed and determined shall be given in writing in duplicate, and shall be signed by each of the members of the board, and one copy thereof shall be delivered to said city, and kept on file by the city clerk, and the other copy shall be delivered to the said company, and such rates shall thereafter remain the rates so to be charged for water until the same shall be changed upon the giving of proper notice as hereinabove provided.

Sec. 5. In the event and whenever any substantial increase, enlargement, alterations, extensions, or additions to said plant and system, or any part or portion thereof, shall be desired by said city, the same shall be made either by said city by special assessment or otherwise, in case the said city shall elect so to do, or by the company, in case said city should so elect.

In case any such change is made by and at the expense of the city, the cost and expense of the operation and maintenance thereof together with the necessary replacements and renewals shall be paid out of and deducted from the income of said company nor shall any addition to the capital of said company be made on account thereof.

In case any such change is ordered by the city to be made at the expense of the company, then the necessary cost and expense thereof shall be paid by the company, and the amount of such cost and expense shall be added to said capital account, and, from the time such added cost and expense is incurred interest shall be paid thereon to said company at the rate of (as agreed) per cent per annum, payable half yearly, and said sinking fund shall be increased by an annual contribution and payment thereto sufficient in amount when computed with interest thereon at the rate of 3 per cent per annum, compounded annually, to equal the amountt of the cost and expense thereof so incurred by said company, computed as an annuity to January 1, A.D., 1938, and the rates for public and private use of water shall thereupon be revised and adjusted so as to produce sufficient income to said company to cover and pay the said additional amounts.

Sec. 6. At the end of the period January 1,1938, provided for under this ordinance, said sinking fund shall be used and applied to pay off and retire the capital or capital account of the company then outstanding, and said water works and system shall thereupon belong to and be the property of the said city without any further payment therefor, and the possession thereof shall thereupon forthwith be turned over by said company to said city for its own proper use and benefit. In the event said city shall elect to purchase said water works system and property at any time, after this ordinance takes effect, upon notice as herein provided, then the amount of said sinking fund shall in like manner be applied to the payment of said capital, and said city shall be liable to pay and shall pay only the difference between the amount of said capital at that time, and the amount of said sinking fund. In case any surplus remains in said renewal or replacement fund at the time of such purchase, the same shall be divided and shall be paid one-half thereof to said city for its own use and benefits, andone-half to said company for its own use and benefit.

Sec. 7. Said company, so long as it continues to operate under the provisions of this ordinance, and on or before the fifteenth day of February in each year, shall prepare and file with the city clerk of said city an annual report for the preceding year ending on the thirty-first day of December.

Such reports shall be made in writing, verified by the affidavit of the secretary or other proper officer of the company, setting forth with reasonable detail according to forms prescribed by the city council, the character and amount of the business done by the company for the year immediately preceding such reports, the amount of receipts, and the expense of conducting said business and the city clerk, under the order and direction of the mayor and city council of said city, shall have the right at all reasonable times to examine the books, vouchers and records of the receipts and expenditures of the company for the purpose of ascertaining the accuracy of the report herein referred to and the rights of the city under said ordinance. The city council shall have the power, within reasonable limits, to prescribe the form and manner in which the books and accounts of the company shall be kept. There shall be also an annual audit of the accounts of the company covering all their receipts and expenditures for the year ending on the thirty-first day of December next preceding, and a formal written report by public accountants selected by the city and the company, the expenses of said audit and report shall be paid out of the gross receipts of the company as an operating expense.

In the event of any purchase of the water works and property of the company under the provisions of this ordinance there shall be an account and report for the preceding six months similar in character to the plan hereinbefore provided.

Sec. 8. The company shall not remove its principal office, or any of its books (except bond register and stock transfer books), records, accounts, contracts, or original vouchers of receipts and expenditures beyond the limits of said city, and shall maintain an office within said city so long as the company continues to operate any portion of the water works mentioned and provided for under the provisions of this ordinance.

Within thirty (30) days from and after the passage of this ordinance the company shall file with the city clerk of the city of Lake Forest an acceptance thereof, in writing, signed by the company, by its officers who are authorized so to do, and thereupon this ordinance and such acceptance shall become and be a contract between the said company and the city of Lake Forest.

Sec. 9. The rights and privileges of said company under said ordinance, entitled "An Ordinance to provide for a supply of water to the City of Lake Forest, Ill., and its inhabitants contracting with the Lake Forest Water Company, their successors and assigns for a supply of water for public and private use, and giving the said City of Lake Forest, Ill., an option to purchase the said works" are hereby continued and extended for the period of thirty years from the date that this ordinance takes effect, expressly subject, however to all the provisions of this ordinance.

Sec. 10. This ordinance shall take effect and shall be in force from and after its passage and publication once in "The Lake Forester."

CONCLUSION

One departure from accepted practice is to be noted, in that section defining how the board of appraisers is to be selected. It is stated that they are

"to be selected and appointed by the city and by the company by mutual agreement, and no one of whom shall be considered, or shall be the representative of the interests either of said city or said company."

The ordinary method of selecting such a board, usual in such ordinance, requires:

The city and the water company shall each select a competent Hydraulic Engineer, not a resident of ...... and they two to select a third member of said appraisal board; the decision of any two of such board to be final and binding.

A long experience with appraisal boards convinces the writer that the latter method of selecting appraisers is vicious and improper. It leads to disputation and partizanship where harmony and concentration of purpose are desired. Being chosen by either side, the two members appointed by the city and company are constantly tempted to differ, and the third member is placed in the embarrassing position of having to decide their differences. Time and energy is often lost by this situation, which should logically be given to a disinterested and fair discussion of the merits of each question before the board.

The method in the accompanying ordinance avoids this difficulty, and, if properly carried out, as it can be in a number of different ways, results in harmonious study and disinterested discussion of each mooted point. The result is reached in less time, without friction, and with greater fairness. This was the method adopted at Quincy, Ill., which appraisal resulted satisfactorily to both parties, and resulted in the satisfactory purchase of the works.

The city of Lake Forest has not adopted this ordinance, although the city officials first proposed the general method and have given it careful study. The fact that the water company was not receiving a fair return, and a slight raise in rates would have been necessitated, accounted for failure to act.

The ordinance was prepared and perfected by Mr. N. A. Partridge, attorney of Chicago, and the writer.

DISCUSSION.

MR. DABNEY H. MAURY: Mr. Alvord, as usual, has been one of the pioneers in proposing a method of adjustment of the difficulties between invested capital and the municipality; and the method which he here presents is so fair, so manifestly equitable, that it must commend itself to every one who studies it. I think it is impossible for any one to read the proposed form of ordinance without feeling that all the way through fairness has been the one thing in view. The advantages to both sides must be evident. Fairness is assured in the very first provision for the choosing of a board of arbitration, who are, as stated, not to be employed by either of the parties, nor to be paid by either, but are to be appointed in some manner that will be mutually agreed upon, to serve both parties jointly and to be paid by both jointly. This takes the whole proposition out of the realm of the town meeting, and the partisan argument which so often obtains in appraising, where the man who can best put forth his side of the case wins to his side the third appraiser, and thus perhaps gets an unfair advantage.

One of the provisions of this admirable ordinance is for a sinking fund to retire the investment at its termination; this sinking fund, or such amounts as may have accrued in this sinking fund, to be applied on the purchase price to be paid by the city to the company when the city shall elect to purchase. Now if the city should make up its mind that it would be thoroughly sure of fair management and of fair rates under this sort of an agreement—and it does seem to me that no other kind of an agreement could carry fuller assurance of these benefits—if the city should feel assured then that under this ordinance the rates would be fair, that the plant would be continually maintained, that extensions would be made when they were really needed and when it was proper that they should be made; and if it could see all the accounts and expenditures, and there would be no loophole either for political meddling or for unjust overcharges on the part of the company, then the city might well say to itself, "Why do we need to buy this plant? Cannot we save on our rates by doing away with the sinking fund? When we decide to purchase, if we do purchase, of course the company is entitled to have the fair value of its plant; but if we can get along better in this way, and can save 1¾ per cent on the investment, why not cut out that sinking fund provision, and get along without it, and have rates lower by just that amount?"

On the other hand, if the city prefers to retain—and that is always an attractive thing to the average municipal management—the privilege of purchasing, then purchase is made easy by the fact of this sinking fund, which will go on accumulating if invested in the best possible manner, so that the city will have a savings account against the time when it may wish to acquire the property.

Some months ago I had an opportunity to present this ordinance for the consideration of a municipality by which I was retained. I think in that case the company was the one which received it with somewhat less favor than the city. The matter has not yet I think been definitely settled, so that I cannot tell at this time whether the ordinance has been adopted; but when it was read to the waterworks committee the men who seemed to me to be the cleverest men of the lot were struck at once by the possibilities of the sinking fund proposition. One said, "Well, I will tell you what I think this city would do when the franchise expired and it was up against the option of turning over the sinking fund to the water company, taking the plant, and going on and operating it; I think the city would say to the water company, 'You just give us your sinking fund, which represents your capital account, and you take the plant and keep on operating it.'" I think that man was right. I think that is probably what a wise city administration would say under such circumstances. I think that they would probably realize by the end of that period two things; first, that they had gotten fair rates and fair service all the way along in the management of the plant, and that they had been able to control and dictate its extensions; and I think that the city, by the time thirty years had expired, would feel that it had better spend the sinking fund for something else.

In submitting this ordinance, or what was to a large extent a copy of it, to my client in this particular instance I made one change which I think was a somewhat important one, one which I shall certainly recommend in all cases of this sort; namely, that the item of going value to be figured by the appraisers should be figured not on the existing rates—unless those rates are fair—but should be figured on a basis which would give fair returns as estimated by the board. It would be manifestly unfair, I should think, if a company had been earning a greater rate of interest than that to which it had been entitled, to allow it to capitalize excessive profits and continue to earn interest on them. On the other hand, if the company in the past had not been earning enough money it would be equally fair that the going value which, if figured on its rates would be an insufficient going value, should be figured on rates which would be fair.

And in conclusion I would submit this particular form of ordinance to the very careful consideration of every one who is interested in this problem which confronts so many of us now; and I should like to congratulate Mr. Alvord once more on being one of the pioneers in its preparation.

Mr. Dow R. Gwinn: I want to add my approval to Mr. Alvord's ordinance. It seems to me that that is a sane solution of the ownership of private waterworks, that it will enable cities to get all they want, and at the same time ensure to capital a fair return on its investment.

Mr. J. W. Ledoux: I know of a case where there was a dispute between a large railroad company and the water company, and it was agreed that the dispute be settled by the engineer of a waterworks that was not interested in either concern but who was to be appointed by the president of the American Waterworks Association, or the president of the American Society of Civil Engineers in case the Waterworks Association was not in existence, and that in any event the man to make the appointment was not to be interested in either concern.

L. J. Le Conte (*by letter*): Public Utility Corporations are always in hot water. This arises from the fact that the interests involved are mutual and interlocking, and you will find that they cannot be separated, while the business end of the enterprises is always largely in the hands of the corporations (who are too frequently lacking in tact), and, generally speaking, we may say that good judgment is wanting on both sides.

This irresistible conflict has reached such a crisis in San Francisco and Oakland, California, that both cases have been taken to the United States circuit court of appeals, and this court has issued permanent injunctions prohibiting reduction in water rates—thus constituting what is locally called "Government by Injunction." These decrees are still in force. Of course, this state of affairs ought not to exist in any enlightened community, since it shows unmitigated partisan spirit of the worst type.

This remedy by injunction has been very severely denounced and criticized on the ground that it places in the hands of the judge, legislative, judicial and executive powers; that it enables him to make the law for one case against a particular individual, and if he does not abide by it, to try him and punish him. When this objection is properly analyzed, however, it is found to be unjust. The only men who reap any benefits therefrom are the lawyers.

The suggestion of the author that the municipality should become a more active partner in all new contracts and franchises, seems to be an important step in the right direction; and I still have some hopes that this scheme may alleviate the growing troubles to a marked degree For example: The water company at Oakland has recently offered to sell 55 per cent of its stock to the city—thus giving it a controlling interest in the management and operation. Likewise, the water company in San Francisco has offered to sell out all the physical plant, now in actual use supplying water to the city, for a moderate sum, and much less than it would probably cost the city to bring in a new supply from Hetch-Hetchy Valley, as contemplated.

Both these propositions and offers are now being taken under advisement and it remains to be seen if any good results may develop.

The suggestion in regard to the "Board of Appraisers" is highly commendable, and will certainly elevate the whole tone of the board. and render their work much easier and more reliable in every way.

MUNICIPAL OWNERSHIP

PARK WOODWARD

Much has been said and written both in this country, and in Europe for and against the policy of a municipality owning and operating public utilities. There are few more attractive theories than municipal socialism; but it may be also said in practice, they have generally proven failures.

The main arguments used for and against this public policy are severally worthy of consideration. Many of them are good on both sides of the subject as far as they go, and in certain cases, and under certain conditions are sound, but in most cases these arguments made as they are by interested parties on one side or the other, are generally based on theory, while they lose sight of common sense facts.

The term "utility" when used by writers on Political Economy in reference to public ownership, is construed to mean that policy which contributes most to the promotion of human welfare and is profitable to the public generally, and the term "utilitarianism" is the doctrine that the greatest good and happiness to the greatest number should be the sole aim of all public action. This being true, does the owning and operating of public ulilities by a municipality, conduce to this general public good? The main argument in favor of municial ownership is based on the idea, that if a private company can successfully operate a plant and pay large dividends to its stockholders, a municipality could do the same, and that the large profits which go to the stockholders could go to the public in the shape of lower rates and better service, and at the same time result in the reduction of taxes, and thereby benefit the public generally.

Another argument in favor of municipal ownership is, that all large monopolies, who own public franchises, are the principal cause of corruption in municipal government, through their attempts to control legislation to secure and keep their franchises and to enlarge and increase their privileges, without regard to the public interest, and that the municipality owning and operating these franchises direct, would remove these corrupting influences from the community.

Another argument in favor of municipal ownership, is that a municipality can borrow money at much less rate of interest than a private company, and can therefore build and operate a plant at much less cost, and for the further reason that they would not have to provide for dividends to original stockholders and for watered stock, but all the profits, after operating expense, interest and cost of maintenance etc., is paid, the general public would get the benefit of in reduced rates, and that if profits beyond an amount sufficient to pay all expenses is had, rates to consumers can be reduced to a minimum, and the surplus if any can be applied to the general fund and used in the operation of other departments of the municipality, thereby decreasing the tax rate.

Another argument used, is, that by the municipality owning and operating its own plant, the standard and condition of labor can be improved, as the city will be in a position to pay better wages without materially increasing the cost of production, as in the case of a private company.

It has also been argued that in a majority of cases where municipal ownership has been tried, the results have been satisfactory and that the cases of mismanagement are more than off-set by the cases of mismanagement of private plants in their dealings with the public.

AGAINST MUNICIPAL OWNERSHIP

The main reason that has been advanced against municipal ownership is the supposed political corruption of American city governments, which it is claimed results in the appointment of inefficient officers to important positions for political or personal reasons, and without regard to the public good or the safety of the public service, and which often results in mismanagement and sometimes in disaster, and that the public interests are not safe in the hands of such men, who are influenced mainly by political reasons in the management of these plants. For the man who exercises power, it is dangerous for him not to have an eye open to the interest of the same powerful class or faction who have put him in power, and whose interest he serves without regard to the public welfare.

Another argument is, that in a municipal plant, the officials, in the effort to gain the favor of the public, are liable to reduce the rates to consumers to such an extent as to make the plant a public burden rather than a profitable investment, or they are liable to go to the other extreme, in an effort to make the plant show large earnings and in this manner reduce the tax rate, which would result in the consumer who pays no taxes having to bear the burden of an unjust tax in the shape of high rates.

Another reason argued against municipal ownership, is, that as a rule municipal governments are not progressive in the matter of improvements, or of extending into and developing new territory for the public convenience or benefit, nor are they generally prone to the spending of money for testing new methods of operation, etc., which have in view the improving and cheapening the cost or service; and it is also claimed that the cheapness claimed for city operation of industries is more apparent than real, and they call attention to the fact that in many cities which have undertaken municipal management of enterprises no provision is made in the accounts for deterioration, wear and tear on machinery, plant, etc., and if such provision is made, it is not equal to what many experts have declared sufficient, and that this item of expense will ultimately become a burden to the community.

CONCLUSION

The question of municipal ownership has two sides to it, but with all the argument against it, and apparently good and sufficient argument, it goes without saying that any enterprise in which the general public is directly interested, should be owned and operated for their benefit.

The same enterprise owned by a private company is operated on the idea of paying a good profit to the investors, and this without regard to the public interest generally.

Municipal owned enterprises in some instances have succeeded but in many have failed to come up to public expectations. These failures can all be attributed to the same cause—the injection of politics in the management. But that is no reason to say that it cannot be made to succeed. No enterprise can succeed if not run upon strictly business principles. The cost of operating, maintaining, etc., should be on the same basis as if owned and run by a private company. One great trouble about municipal ownership is where a plant is run on political ideas and not strictly business principles; the general public look upon it as their individual property and think they have a right to criticise or condemn at any or all times matters that a private company would do without question for the benefit of their property, and their suspicions are aroused concerning matters they do not and cannot comprehend, and they are disposed to think that there must be some motive besides the desire to promote the public interest, or to take care of the public property which prompts the expenditure of money for necessary improvements and additions. This condition of course makes it exceedingly unpleasant for one to hold a responsible public office in such a plant. In every municipal plant, run politically, the management is daily importuned by officials of the city government, and by politicians to appoint men to positions who are totally unfit to perform any kind of service, and failure to make a place for such a one or a discharge of one for failure to perform his duties or for any cause, results in building up among his friends and associates, a host of enemies against the management. A municipal plant run on as strictly business principles as a private plant, would be extremely unpopular. The officers and men could be at all times subject to insults and opinions detrimental to their honesty and integrity. If the plant is successfully operated, it would make it that much worse.

The only way to run a municipal plant successfully and for the public benefit, is to eliminate politics absolutely, and pay no attention to public criticism. To do this would require the adoption of a policy and the passage of laws contrary to our socialistic idea of government, but there is no way to operate a municipal plant successfully otherwise, than by those in authority being eliminated from political obligations or influence of all kinds. Municipal operation of public utilities will never succeed until we realize the fact that business principles alone should be considered in the management and operation. If this cannot be accomplished, then it would be much better and safer for the community that private companies should operate all public utilities if they could be controlled in their dealings with the public so as to prevent oppressive rates. While the rates under private services, would be perhaps more than under politically managed municipal services, still the cost to the municipality would be less, where cost of operating and maintaining a municipal plant under political management is more than the income, and the saving to the general tax-payer would more than compensate for the increase in rates.

These views are presented for what they are worth. The questions involved are serious ones, and will never be satisfactorily settled until some way is adopted to put municipal plants on precisely the same basis as private plants, or until private companies are satisfied to run these public utilities at a reasonable profit, and let the general public receive some benefit from their own property, or such legislation is had as will authorize the granting of franchises only on such terms and consideration as will guarantee to the tax-payers and the public generally fair treatment.

To sum the matter up in brief—municipal ownership operated on *strictly* business principles, with all politics eliminated is a good thing for any community.

With politics injected in any manner in the operation or management failure will be the inevitable result.

STERILIZATION OF WATER

WALDEN AND POWELL

The sterilization of public water supplies has been the subject of careful investigation by many municipal and private corporations for the last two or three years, and more so in the past year, owing to the shortage of water and the fact that many supplies, including wells, reservoirs and small streams became badly polluted due to wash when there were rains, and at other times when there was not sufficient water to properly flush the streams or surface to prevent pollution from such wells through the sand strata. These investigations have invariably met with the obstacle which has been the stumbling block in all such enterprises, that is, first cost and operating cost of the purification system.

The Baltimore County Water and Electric Company have been operating a filter plant for a number of years, and being desirous of obtaining a cheaper method of sterilization, have from time to time been investigating the various methods of filtration, namely, slow sand, American or rapid sand, and the up-draught system of sand filtration here, as well as the European. This company has also experimented for several years with the application of alum and hypochlorite of lime applied directly in the reservoirs or storage basins themselves, with considerable success, as will be shown in this paper.

In addition to the above-mentioned careful investigations, the sterilization of water by ozone was considered about two years ago. A company controlling valuable patents submitted a sample 3,000 gallon ozone sterilization plant for test, which was placed alongside the American or rapid, and slow sand filters, handling raw water directly without sedimentation. Some of the results obtained from this sample plant have already been reported in the previous paper on the use of hypochlorite of lime, which has also been in use both in the American and English filters for some two years. The results from the use of hypochlorites are given in the form of curves in this paper, from careful tests made by our chemist, Mr. Shepherd Powell. In addition to these tests, a rough determination of the amount of nascent oxygen in a grain of chloride of lime has been made, and the approximate calculation of the volume of gas on a basis of .1 grain per gallon, to get an approximation for the volume of ozone, which was roughly .00096 cubic inch per gallon, but this depends upon the concentration and will vary with the condition of operation and temperature. The specific gravity of ozone throughout the test has been taken at 1.65, as compared with air as 1.

With the data at hand, the ozone plant at Lindsay, which had just been started, was investigated, and it was decided to install a sterilization plant at the Herring Run Station of the Baltimore County Water and Electric Company, to have an ultimate capacity of 10,000,000 gallons in 24 hours with roughing filters to remove the suspended matter, to handle the raw water at double or triple the usual rates per unit area in rapid or American sand filters. Plans were gotten out and work started, but considerable difficulty was met with owing to quick-sands. The sterilization pit was thirty feet deep and within twenty-five feet of the river bank. The walls were not completed until it was late in the fall. Work had to be abandoned during the winter other than to test the many different kinds of mixing head or aspirators, including various nozzles, converging tubes, orifices, etc. Sheets Nos. 1 to 7 B.

As it was important to get information as to the amount of air that could be mixed with a given volume of water under our low head, it was found that under low heads some aspirators would not give a continuous draught of ozone or air, and when the draught was heavy, the spcific gravity of the mixture would become so light that there would be a blow-back, which would momentarily blow the ozone input back, and while it was possible with low heads to get about one-third ozone to water in volume, the lowest point or head that should be considered is about twelve feet. Though some changes which were made in the design of this plant and adopted at Ann Arbor, Mich., No. 9, will allow the use of heads of from six to ten feet, same will not give a steady input of ozone, as it is intermittent. This, together with the use of a small blower, seems so far to be satisfactory.

The area required for plant of size installed is only about one-tenth that required for American plant, and is not to be compared with the area required for slow sand filters. From the plans it will be seen that the sterilization plant proper constitutes raw water chamber, aspirator heads, ozone chambers, ozone generator, as well as time contact basin or mixing cell. The latter compels the water to travel horizontally as well as vertically, so as to give water the benefit of as long contact as is possible with ozone.

The prints and photographs will give you an idea as to how many experiments have been made, and the design of the pressure heads and nozzles. Nos. 10 to 14. The results of the many tests of the different cones will be given in some subsequent paper.

The ozone generator consists of boiler plate, shell and head, 30 inches high, 33 inches diameter, containing each 109 two inch aluminum tubes, inside of which are micanite tubes or dialectrics, inside of which is another tube or cylinder which rests on a tray, which is connected to one terminal of a special 10,000 to 15,000 volt static transformer. The other terminal, which is a ground terminal, is connected to boiler plate shell; inner and outer tubes being so close and only separated by micanite tube, allows a continuous violet discharge to take place through the dialectrics, and the passage of air through this discharge produces the ozone, the production running from eighty to one hundred grammes per k.w., and the concentration of five or less, depending upon the condition, velocity and the temperature of the air discharged.

Sparks must be prohibited, as when a sparking condition takes place nitrous oxide is generated, and also high temperature should be provided against in the generators.

There is under construction another type of ozone generator, which from test on a small experimental unit has given as high as sixty grammes of ozone, with concentration of twenty, but it is too soon to say how this will work out in much larger sizes. This company expects, however, to have one of these generators in use soon for test, and more definite results will be obtained. The ozone generators may be either water, oil or air cooled. If it is air cooled, the outer shell has to be removed and the top and bottom heads supported by four rods, or a frame used, and air caused to circulate by any means between and around the outside of the fixed tubes.

The ozone generator in use here will be cooled by oil, to prevent, if possible, the sweating of the tubes when water is the cooling medium, as the oil will remain warm for some time after current is cut off, preventing moisture collecting and giving trouble at starting. The only trouble to be feared with oil cooled system is leakage, owing to the fact that it is a hard matter to get joints that will stay tight under oil pressure, although the pressure will not exceed from two to three pounds under any condition. Oil is circulated by means of small ½ h.p. motor belted to rotary pump, the oil being passed through copper coils in a tank or cylinder through which water is flowing continuously. Each generator has its thermometer for determining the temperatures, and a controlling panel on which will be mounted indicating wattmeter, potential transformer plug, high tension switch, voltage regulating head which will permit of handling 2300 volt current on the primary side of the transformer in such a manner as will give voltage of the secondary side of the transformer range from 7500 volts to 15,000, or to be varied to intermediate volts. In addition to this there is a voltemeter reading to 15,000 volts, power factor meter, and frequency indicator. These panels are located over a concrete vault in which are located the transformers. Each million gallon unit requires 5 k.w. transformer capacity. All the switching is done at 2000 volts on the primary side, and the high tension side is connected directly to the ozone generator through varnished cambric lead incased cable two-conductor, placed in bituminized fiber tubes, encased in concrete.

Owing to the weather conditions and the fact that some of the apparatus for this plant, such as insulators, etc., No. 7 A, were special, and the departure from the original design, continuous tests have only just begun on this plant.

Considerable information was obtained, on some of which further experiments will be carried out, to determine what would appear to be the slip of the bubbles of ozone or air, and the fact that they do not seem to fall at the same velocity with the water, or for some reason do not receive or hold the kinetic energy imparted to them, and the fact that the bubbles seem to rise at about .75 of a foot per second, this together with the fact that the specific gravity of the air bubbles and water, when the amount of ozone or air reaches certain entrainment, is so low that it loses its kinetic energy and the blow-off is caused, previously mentioned, and is similar to the action of the air lift, the mixture looking like soap bubbles in the down pipes momentarily.

When the temperature of the atmosphere is at or below zero, the strength of the ozone seems to be greater, and the absorption by the water varies as the strength of the ozone given off by the water in the relief chamber over the time contact basin or pit is noticeably less to the smell, and a longer or shorter time is required in high temperatures or extremely cold weather before the ozone is noticeable. But the ozone in this relief chamber becomes noticeably thin when the temperature is high, but varies. Bunsen and Carius found that one-hundred volumes of water near freezing absorb four volumes of oxygen and two volumes of nitrogen, and the absorption is quickened by stirring or mixing. Tests are under way to ascertain more fully this relation to the absorption of ozone as water absorbs more air, and the more of it the lower the temperature; also it absorbs more oxygen than nitrogen. It is to determine this relation when ozone is mixed with water, as no data are available at the present time, that experiments are being made. From this, it seems that these gases when absorbed are given up as pressure lessens, that is, given up in minute bubbles, similarly to water which is highly charged with air, and allowed to stand in a glass, which gradually becomes clear at atmospheric pressure. A cubic foot of water holds in solution about .029 cubic feet of air at about freezing point, and it is possible that the absorption or change increases or decreases the CO_2 in the water when ozone is applied.

The generators require about eighteen watts per square foot surface in the electrodes at sixty cycles, and twenty-one watts per square foot at one hundred cycles, but it is hoped to materially reduce the wattage with the new form of generators.

The following prints, together with the experiments carried on by our chemist, Mr. Powell, which are a part of this paper, will give a pretty fair indication of what the plant consists at the present time. The prints with the numbers, 1, 2, 3, etc., show respectively the electrode, micanite dialectric, tray, generator, shell and tubes, and the small experimental head having forty-two enameled tubes similar to the larger size in use, which has sixty tubes, each.

The tests below, which have been carried on under Mr. Powell's supervision, will undoubtedly prove very interesting.

Ozone Results

DATE	BACTERIA		COLI		COLOR		TURBIDITY	
	RAW	OZONE	RAW	OZONE	RAW	OZONE	RAW	OZONE
December 10–09	1840	6	2/4	0/4	20	15	15	15
11–09	1800	8	4/4	0/4	20	14	16	14
13–09	15000	80	4/4	0/4	45	12	180	180
14–09	4000	1620	3/4	1/4	35	28	80	80
14–09	4000	1410	2/4	0/4	34	30	80	80
15–09	1950	22	1/4	0/4	16	11	20	20
16–09	1500	960	1/4	0/4	16	10	18	18
17–09	1120	870	1/4	0/4	16	12	18	18
18–09	1960	1500	2/4	0/4	17	12	20	20

14th, 16th, 17th and 18th shows the effect of moisture on the tubes.

The company's filtration plant at Avalon, Md., which has already been mentioned, consists of slow sand and mechanical filters, and an experimental ozone apparatus. Since the construction of the rapid filters, about two years ago, hypochlorite of calcium has been used for sterilizing the water in connection with filtration at this plant. The hypochlorite has not been used continuously, as at times the raw water contains but a few hundred bacteria per cubic centimeter. The object in using the bleach has not been necessary because of the failure of either system of filtration, but to lessen the cost of operation and at the same time to deliver water which was practically sterile.

Experiments also were carried on in the laboratory for a better knowledge of the action of the bleach upon the raw water, and to determine the bacterial efficiency under abnormal conditions.

The hypochlorite of lime used was received in 750 sheet iron drums. Only a small opening was cut in the drum so that it could be tightly sealed to prevent rapid deterioration of the chemical. Average analyses of the bleaching powder contained 34.2 per cent of available chlorine. A 0.5 per cent solution was used and was applied to the water through a graduated orifice. The storage solution tanks are of reinforced concrete and have a capacity of 41.5 gallons. The solution flows from the storage tanks to the orifice boxes which also are made of reinforced concrete. The head of solution upon the orifice is kept constant by a valve controlled by a ball float. The tanks and boxes before being used were painted on the inside with elaterite paint, so there has been no trouble from leaking. The orifices were graduated at the plant and have been checked from time to time as to their accuracy.

In making up the solution, the required amount of bleaching powder is first dissolved in a small quantity of water to insure thorough breaking up of all lumps. This solution is then put in the storage tank and the required quantity of water run in.

Under ordinary conditions the capacity of each tank is sufficient for four or five hours' supply. By making up the solution so often, the hypochlorite does not lose its strength to any appreciable degree, and it is not necessary to change the setting of the orifice unless there is a change in the character of the raw water. No. 15.

The table given here shows the amount of hypochlorite in grains per gallon applied to the water at different settings of the orifice. It will be noted that the chemical is given in grains per gallon and not as parts per million of available chlorine or oxygen. The only object in doing this is that grains per gallon is more easily understood by the filter operators than the other terms mentioned.

TABLE TO BE USED IN THE APPLICATION OF HYPOCHLORITE OF LIME

Capacity of storage tank, 41.55 gallons.
Charge of bleach, 2 pounds.
Orifice graduated in inches.
Rate of filtration, 1,025,000 gallons per 24 hours.

GRADUATION ON ORIFICE SCALE	DROP OF SOLUTION IN TANK IN INCHES PER HOUR	GRAINS OF HYPOCHLORITE OF LIME DELIVERED PER HOUR	HYPOCHLORITE OF LIME	
			GRAINS PER GALLON OF WATER FILTERED, ONE FILTER IN OPERATION	GRAINS PER GALLON OF WATER FILTERED, TWO FILTERS IN OPERATION
1..................	1″	583	.026	.013
2..................	2″	1166	.032	.026
3..................	3″	1749	.078	.039
4..................	4″	2332	.104	.052
5..................	5″	2915	.130	.065
6..................	6″	3498	.156	.078
7..................	7″	4081	.182	.091
8..................	8″	4664	.208	.104
9..................	9″	5247	.234	.117
10..................	10″	5830	.260	.130

There was an apparent increase in the bacterial reductions from the hypochlorite when used in connection with sulphate of alumina, over the reduction obtained when bleach only was used. Experiments were undertaken in the laboratory to determine if this condition existed. Tests were made upon the raw water with conditions as near those at the filtration plant as was possible to obtain. One set of samples was treated with various amounts of hypochlorite from 0.05 to 0.5 grains per gallon of water. To another set of samples were applied the same amounts of bleach, but to each jar of water was added sulphate of alumina at the rate of 0.5 grain per gallon. Several of these tests were made during the year and the curves given here were platted from an average of these tests. No. 20.

Although there was not a great difference in these results, still it is interesting to note that the curve platted from the results when alum and hypochlorite were used runs uniformly below the curve when hypochlorite only was used. With highly polluted water this condition would no doubt be more pronounced than it has been here.

The color of the raw water at Avalon ranges from 5 to 65 parts per million, most of which is not in true solution, but in a collodial state. The water is more highly colored during spring and fall floods than at other times of the year. The effluent from the mechanical filters is colorless at all times, also the effluent from the slow-sand beds, when the color of the applied water is below 20 parts per million. When the color of the raw water is greater than this, there is always some color in the filtered water from these beds.

By the use of hypochlorite of lime it has been possible to reduce this organic stain from 5 to 15 per cent, the percentage reduction depending on the character of the color, the amount present, and the quantity of hypochlorite used.

The curve below, No. 14, shows how the hypochlorite of lime removed color that was in true solution and not in collodial form. The quantity of hypochlorite of lime as used here, as in other experiments carried on in the laboratory, was in excess of that which was used at any time at the filtration plant. The reason for using so much was simply to demonstrate the action of the hypochlorite of lime which was the only object of this special work.

An attempt was also made to determine the effect of hypochlorite upon organic matter as measured by the required oxygen. These experiments, as those upon color, were done at the laboratory and consisted of treating liter samples of raw water with hypochlorite varying from 0.05 to 0.5 of a grain per gallon and determining the organic matter before and after treatment.

From the data at hand, the reduction of organic matter by the use of hypochlorite was hardly noticeable even with water high in organic matter, and when comparatively large quantities of the chemical were used.

To determine the efficiency of the hypochlorite on the operation of the mechanical filters, a two months' test was run. The filters were operated during the month of November, using only alum. During December, from the fourth to the end of the month, hypochlorite of lime was applied with the coagulant. There was but little change in the character of the raw water during this period, so the results can be compared fairly well. By the use of a very small amount of the hypochlorite (averaging 0.087 grains per gallon) it was possible to reduce the alum from 0.87 to 0.58 of a grain per gallon.

The percentage of water used in washing the filters was reduced from 4.1 per cent to 2.9 per cent, at the same time increasing the length of time between changing the filters one hour and ten minutes. No. 17. This reduction in coagulant of 0.22 of a grain per gallon amounts to 31 pounds per million gallons; with the cost of alum at $1\frac{3}{10}$ cents per pound f.o.b. Avalon, the saving was 41 cents per million. Deducting from this amount 11 cents for the amount of hypochlorite used, leaves a net saving in the cost of coagulant of thirty cents per million gallons. The actual saving in the operating expenses really amounts to much more, as to this must be added the saving in wash water and the increased amount of water passing through the filter between cleaning.

The average number of bacteria of all samples of filtered water taken during November was 18 per cubic centimeter, while in December, when the bleach was applied with the coagulant, the average was 8 per cubic centimeter. No. 19.

Tests also were made to determine the effect of hypochlorite of lime upon water of high turbidity. The results from these experiments have shown that as the turbidity increases, the bacterial efficiency of the hypochlorite decreases. This is partly due to the increase in organic matter, which invariably increases with the turbidity, and partly to the bacteria being mechanically protected by the particles of matter in suspension. With water having a turbidity greater than fifty parts per million, the hypochlorite of lime gave better bacterial results, when part or all of the turbidity was removed before treating with the chemical. This work has also shown that with the raw water at Avalon, increasing the dose of hypochlorite about 0.10 of a grain per gallon, but slightly increased the percentage reduction in the number of bacteria. Nos. 16 and 18.

SUMMARY

The use of hypochlorite of lime at this plant has shown that:

The effluent from both the slow sand and mechanical filters can be made practically sterile, with the total elimination of B. coli, reducing the color from 5 to 15 per cent.

To reduce the amount of alum and to increase the length of runs between changing the filters, and at the same time reducing the amount of wash water.

Also that hypochlorite of lime is more efficient when used with alum than when used alone.

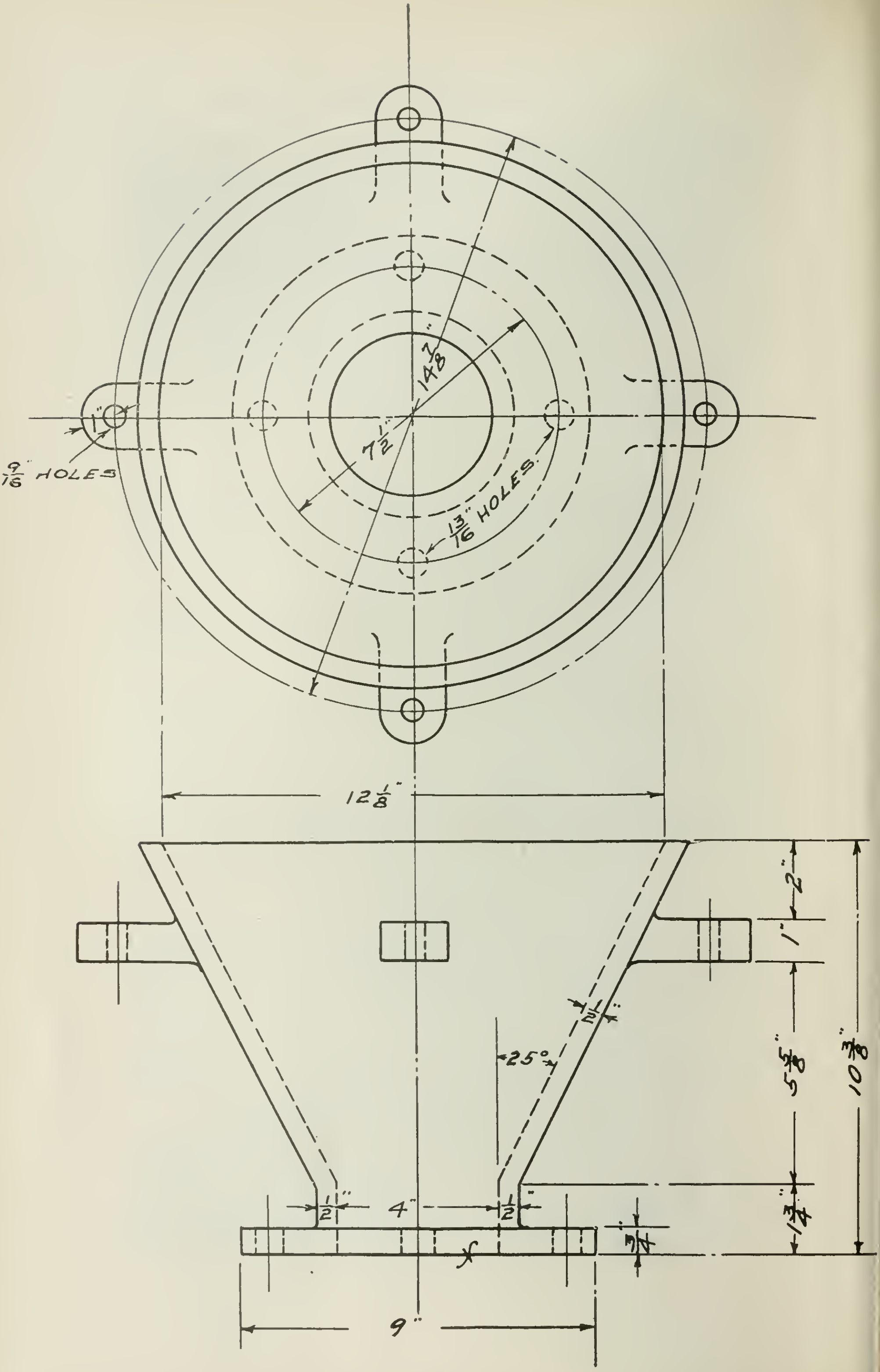
That high turbidity in the raw water reduces the bacterial efficiency of the hypochlorite of lime.

And that the hypochlorite of lime even when used in large quantities causes but a slight reduction in organic matter.

DISCUSSION

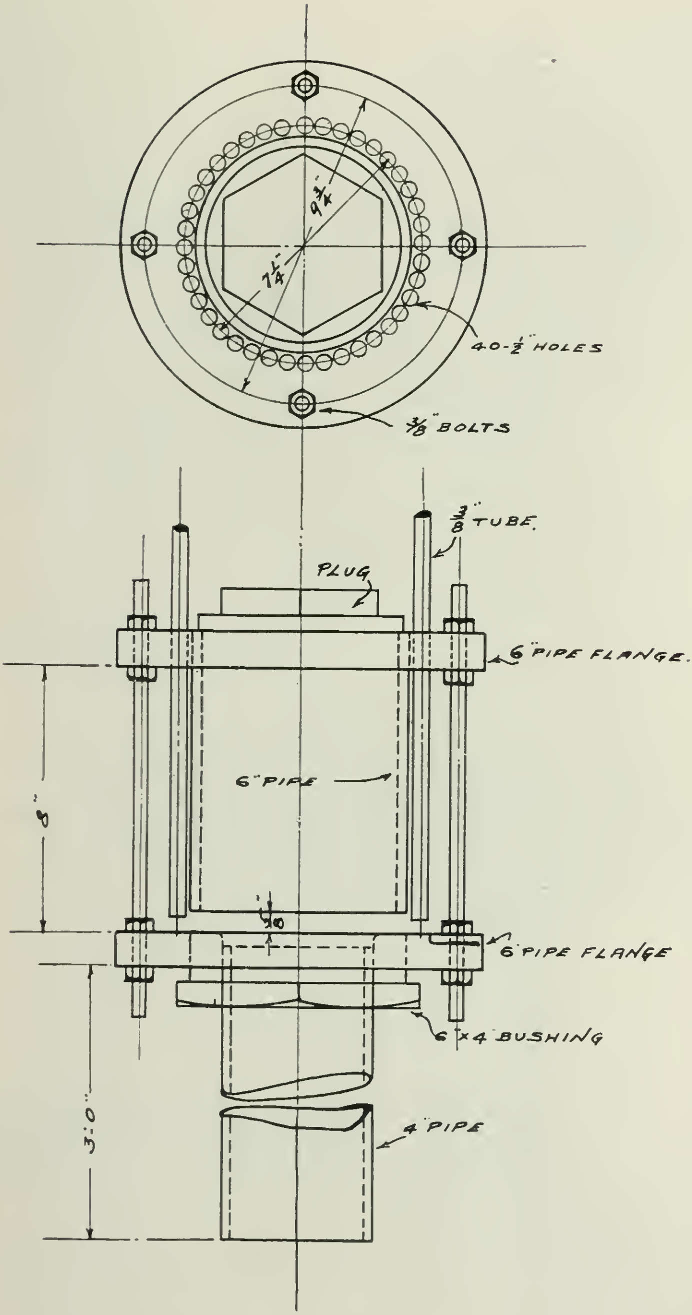
L. J. Le Conte (*by letter*): I am extremely pleased with this little paper. It is full of instruction and fruitful suggestions. What pleases me most is the plain straightforward statement of facts, well presented. To a student of this subject this is certainly very refreshing. The results obtained. so far, certainly hold out strong hopes for greater developments in the near future, touching both bacterial efficiency and economy.

As might be naturally expected with water having great turbidity, the hypochlorite of lime gave much better bacterial results when part, or all, of the turbidity was removed before treatment. Great turbidity is an ugly element which is most economically gotten rid of by proper subsidence.

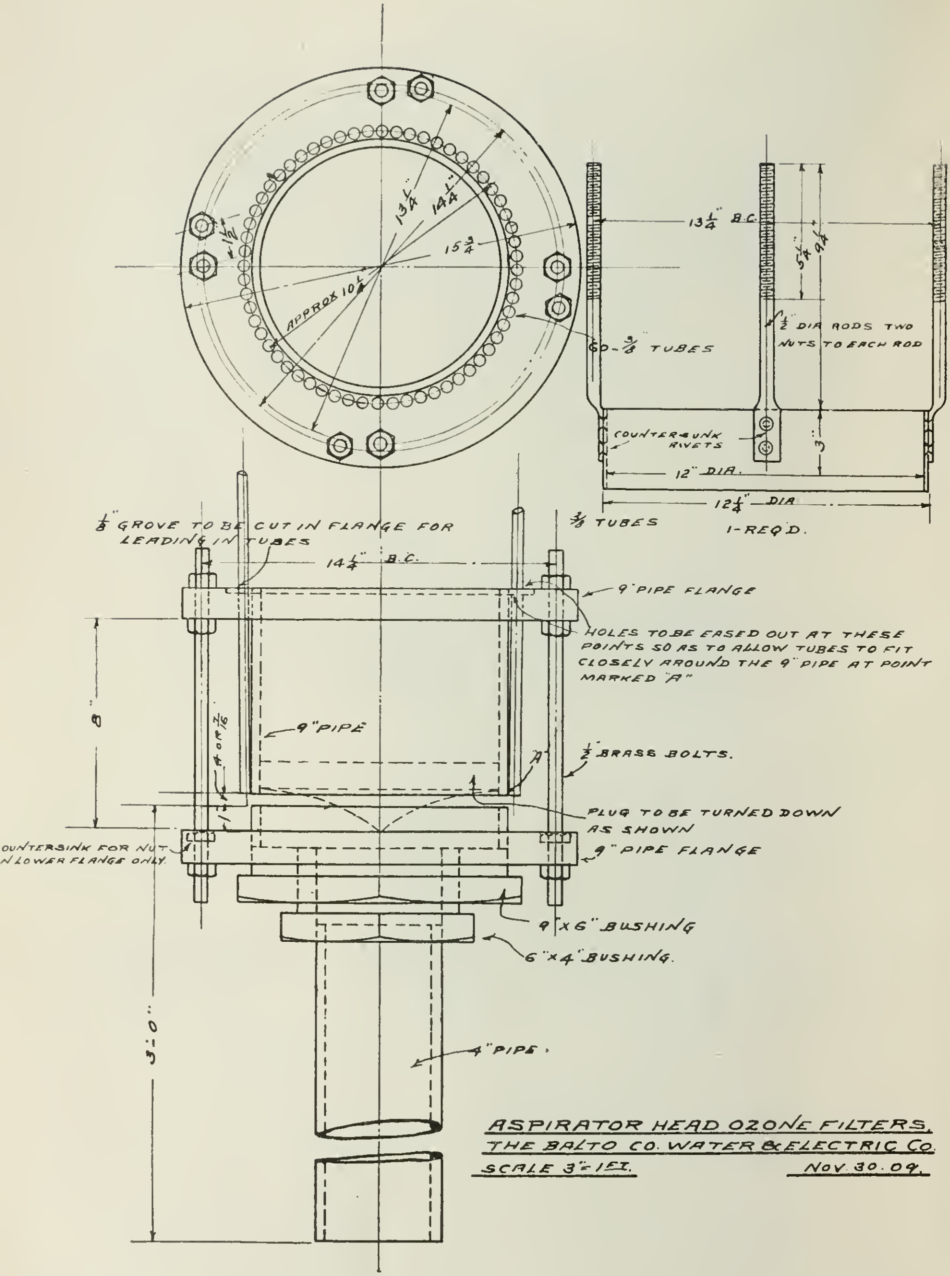


1"
9/16" HOLES
14 7/8"
7 1/2"
13/16" HOLES
12 1/8"
2"
1"
1/2"
25°
5 5/8"
10 3/8"
1/2"
4"
1/2"
1 3/4"
3/4"
X
9"

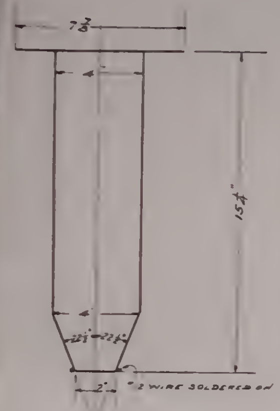
No. 1.

9¼"
7¼"
40-½" HOLES
⅜" BOLTS
⅜" TUBE.
PLUG
6" PIPE FLANGE.
6" PIPE
8"
1/10"
6" PIPE FLANGE
6"×4" BUSHING
3'0"
4" PIPE

No. 2.


13 1/4
14 1/4
1 1/2
15 3/4
APPROX 10 1/4
60-3/8 TUBES
13 1/4" B.C.
5 1/4"
9 1/4"
1/2" DIA RODS TWO NUTS TO EACH ROD
COUNTERSUNK RIVETS
3"
12" DIA.
12 1/4" DIA
3/8 TUBES
1-REQ'D.
1/8" GROVE TO BE CUT IN FLANGE FOR LEADING IN TUBES
14 1/4" B.C.
9" PIPE FLANGE
HOLES TO BE EASED OUT AT THESE POINTS SO AS TO ALLOW TUBES TO FIT CLOSELY AROUND THE 9" PIPE AT POINT MARKED "A"
8"
1/4 OR 7/16
9" PIPE
A
1/2" BRASS BOLTS.
PLUG TO BE TURNED DOWN AS SHOWN
OUNTERSINK FOR NUT
N LOWER FLANGE ONLY.
9" PIPE FLANGE
9"x6" BUSHING
6"x4" BUSHING.
3'-0"
4" PIPE.
ASPIRATOR HEAD OZONE FILTERS,
THE BALTO CO. WATER & ELECTRIC Co.
SCALE 3"=1FT.
NOV. 30. 09.

No. 3.



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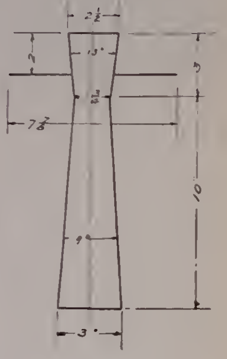

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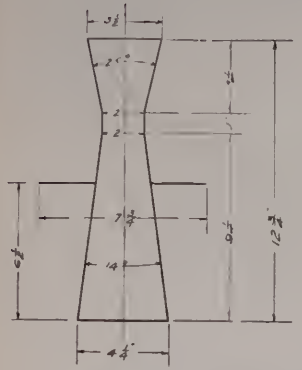

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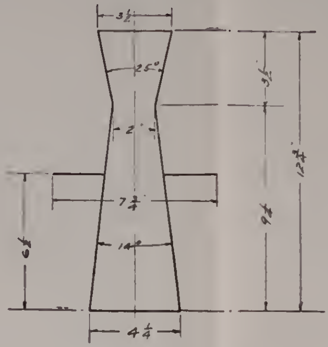

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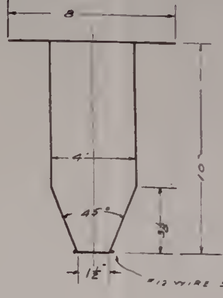

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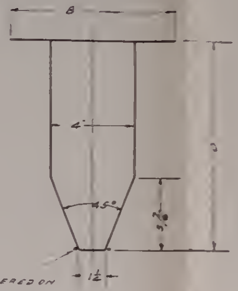

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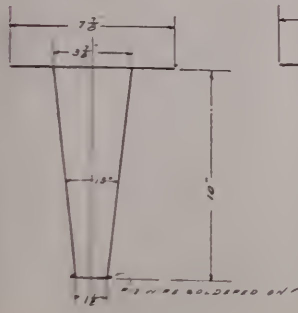

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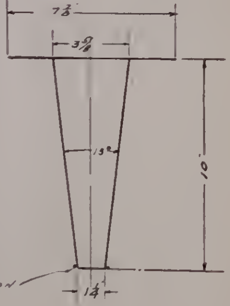

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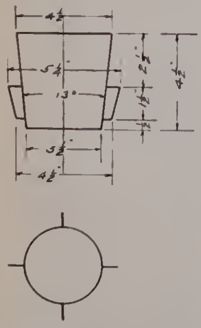

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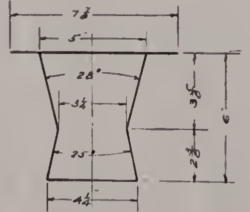

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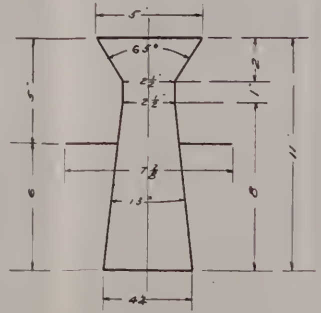

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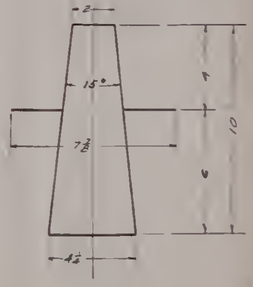

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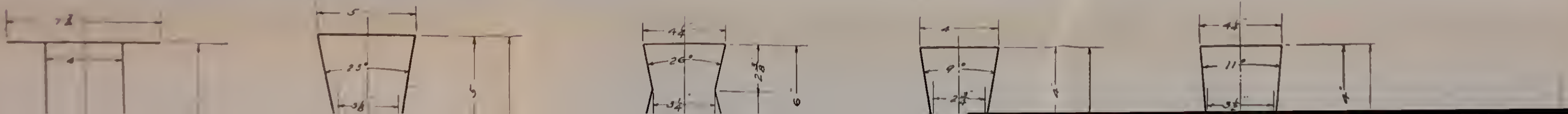

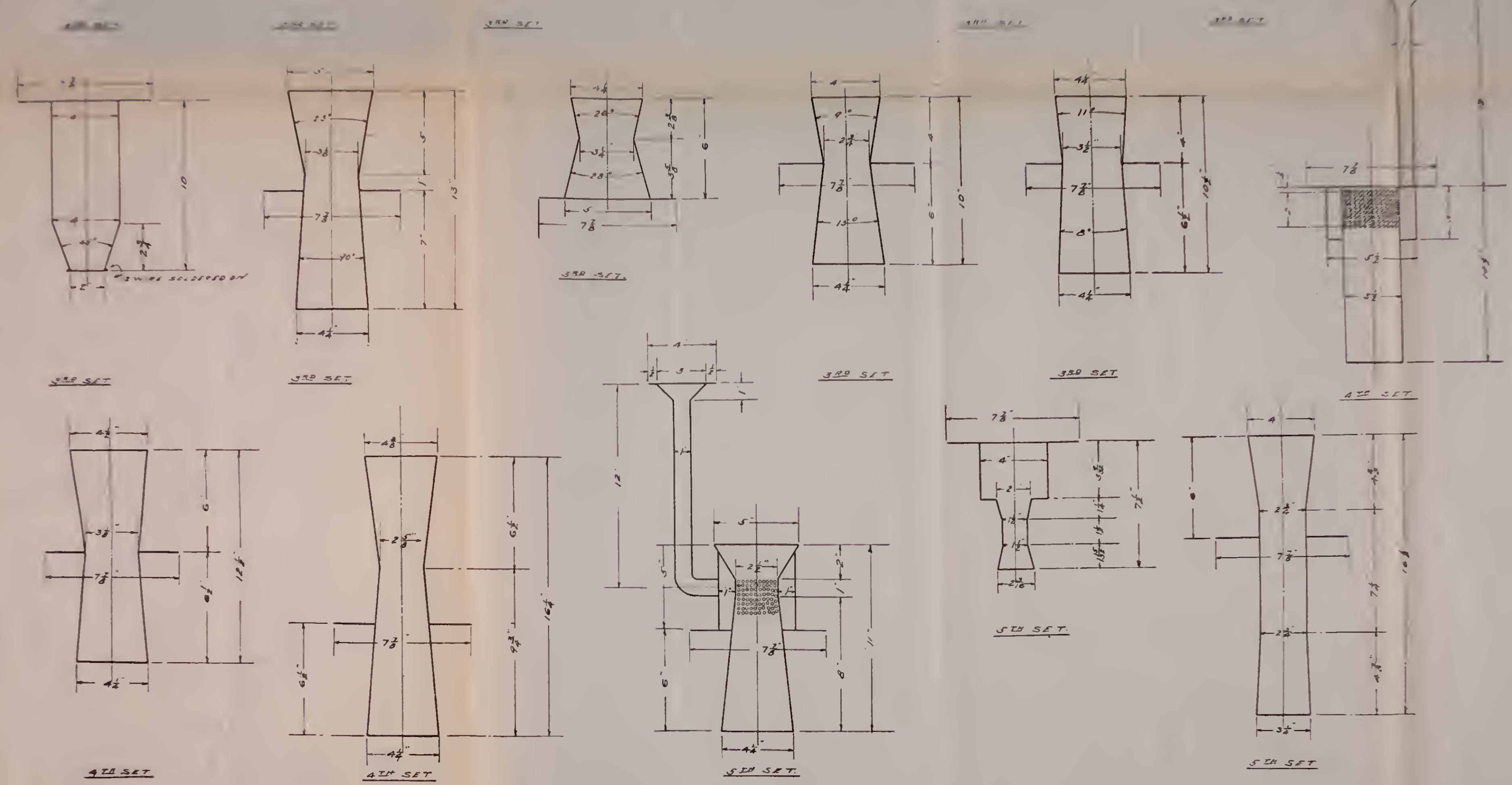

3RD SET
3RD SET
10
2¼
WIRE SOLDERED ON
5
13"
7⅞
4¼
4¼
26°
3¼
28°
2⅜
6
3⅝
5
7⅞
3RD SET
4
9°
2¾
7⅞
15°
4
6
10"
4¼
4¼
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3½"
7⅞"
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4½
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3RD SET
3RD SET
3RD SET
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3RD SET
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4½
3⅞
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6½
16¼
4¼
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4TH SET
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7⅞
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5TH SET
7⅞
4
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1½
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4
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7⅞
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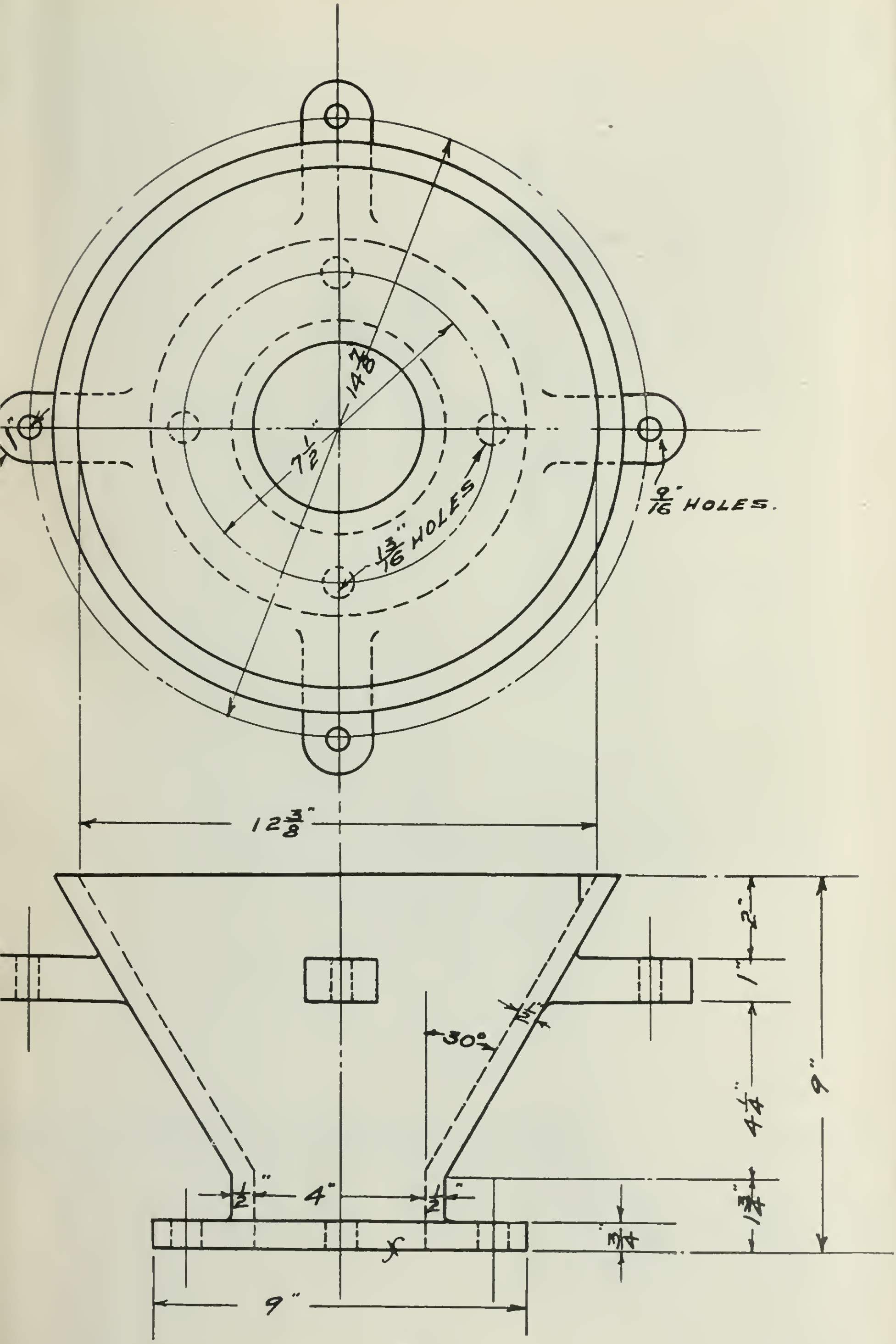
7¼
3¼
5TH SET

No. 4.


14 7/8
7 1/2"
1 3/16" HOLES
9/16" HOLES
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4"
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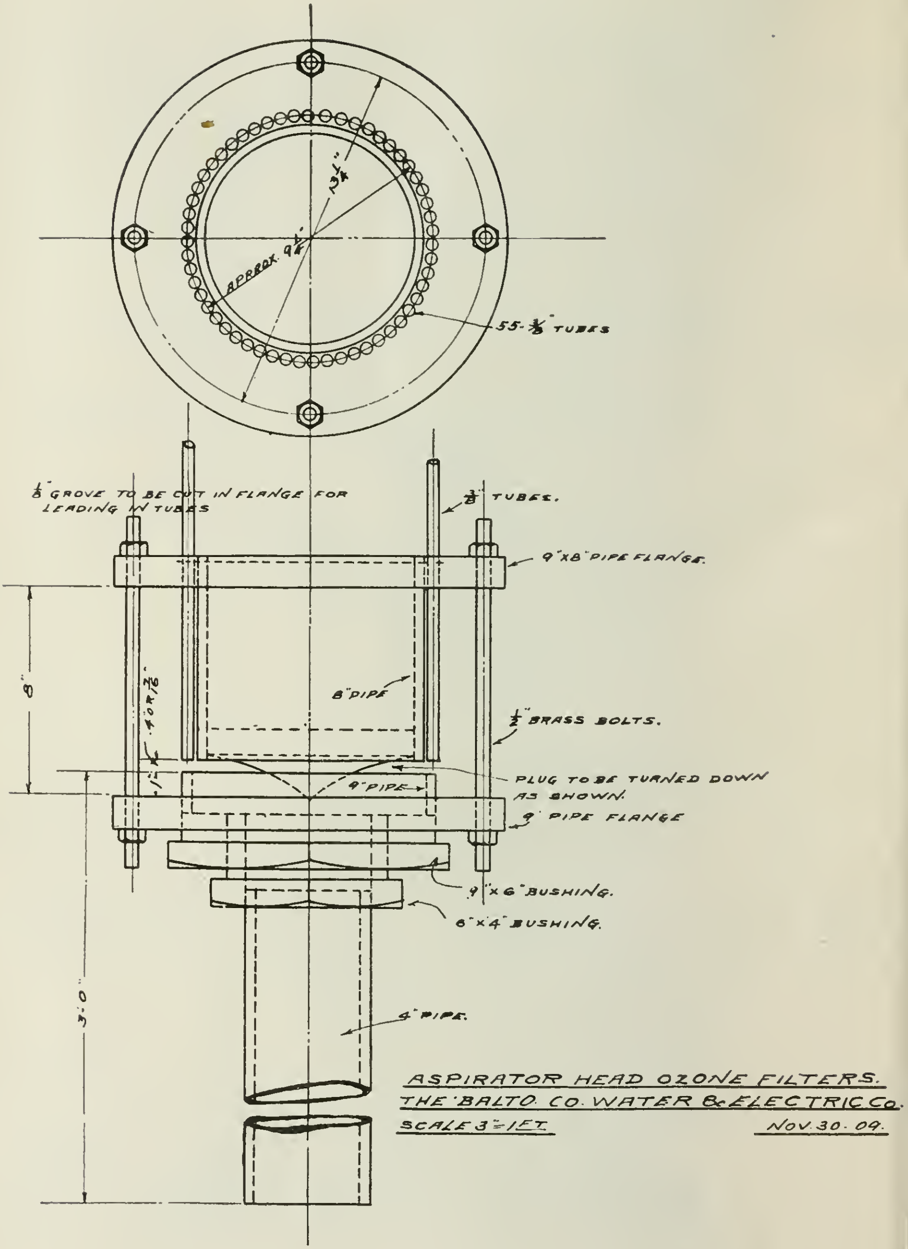
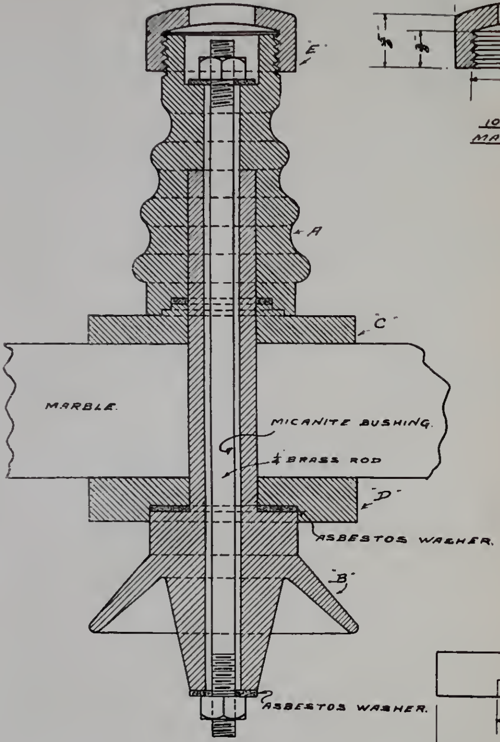
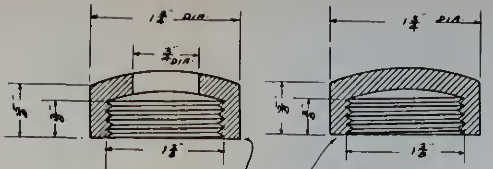
x

No. 5.


13 1/4"
APPROX. 9 1/4"
55-1/8" TUBES
1/8" GROVE TO BE CUT IN FLANGE FOR LEADING IN TUBES
3/8" TUBES.
9"X8" PIPE FLANGE.
8"
4 OR 7/16
8" PIPE
1/2" BRASS BOLTS.
1/2"
PLUG TO BE TURNED DOWN AS SHOWN.
9" PIPE
9" PIPE FLANGE
9"X6" BUSHING.
6"X4" BUSHING.
3'0"
4" PIPE.
ASPIRATOR HEAD OZONE FILTERS.
THE BALTO. CO. WATER & ELECTRIC CO.
SCALE 3"=1 FT.
NOV. 30. 09.

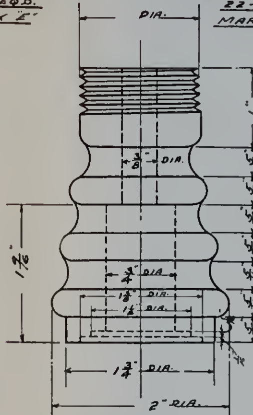
No. 6.



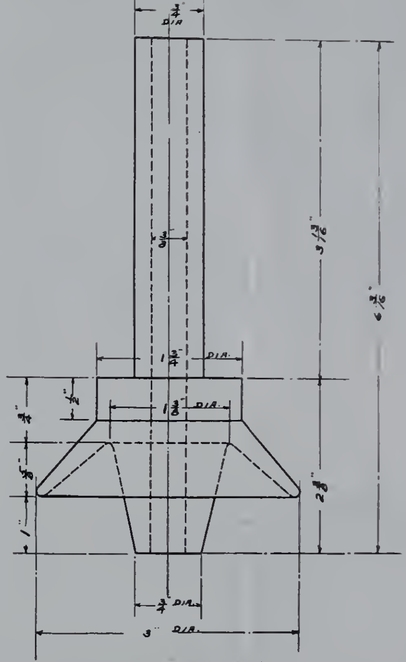


10-REQ'D.
MARK "E"

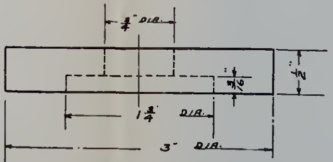
22-REQ'D.
MARK "E"



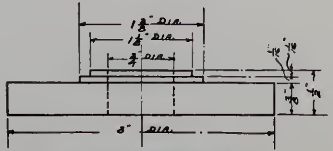
GLAZED PORCELAIN
32-REQ'D.
MARK 'A'



GLAZED PORCELAIN
32-REQ'D.
MARK "B"



GLAZED PORCELAIN.
32-REQ'D.
MARK "D"

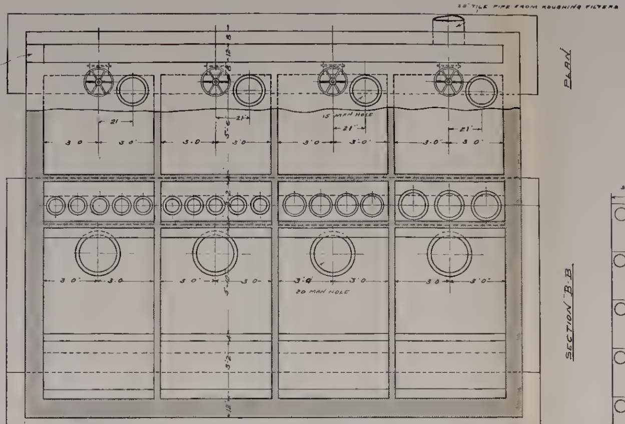


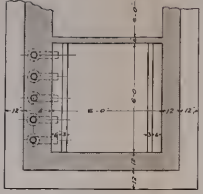
GLAZED PORCELAIN.
32-REQ'D.
MARK "C"

NOTE–
THESE INSULATORS TO STAND 20,000 VOLTS
IN SALT WATER.

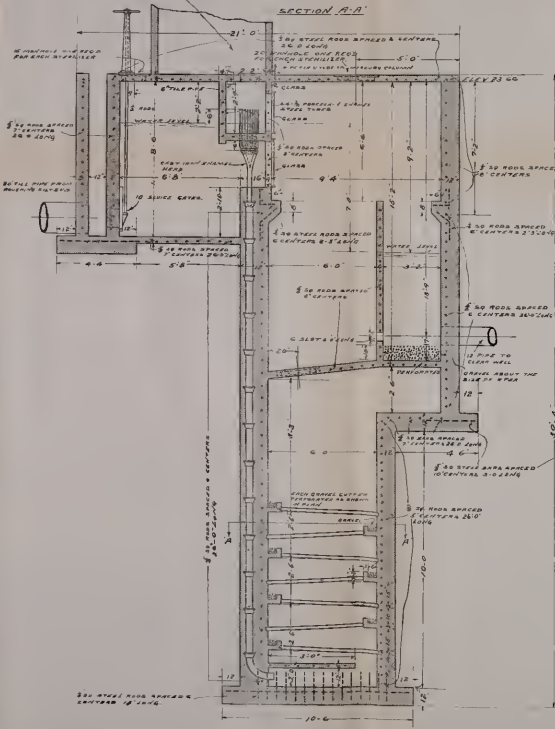
TERMINAL BUSHING FOR OZONE GENERATOR

THE BALTO. CO. WATER & ELECTRIC Co.
OCT. 25-09.
REVISED NOV 2.09

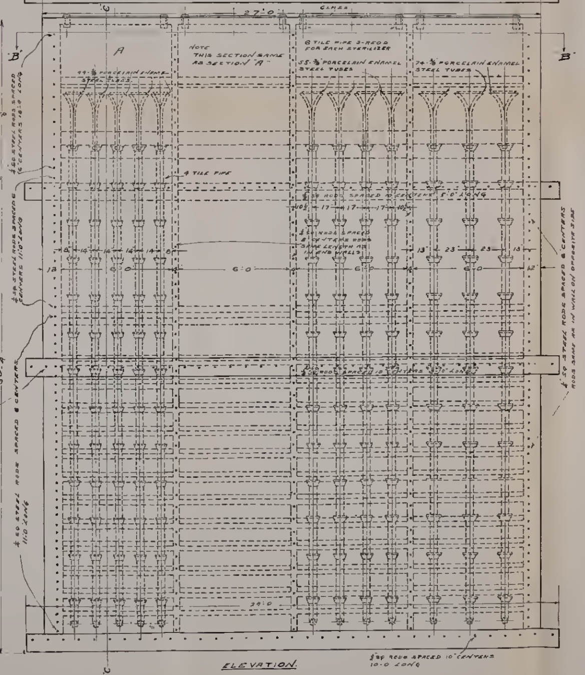

20" TILE PIPE FROM ROUGHING FILTERS
THIS END OF FORE BAY CUT DOWN TO ELEV 21.50 FOR OVERFLOW
12
8
21
3-0
3-0
5-6
15" MAN HOLE
20" MAN HOLE
PLAN
SECTION "B-B"



SECTION "A-A"

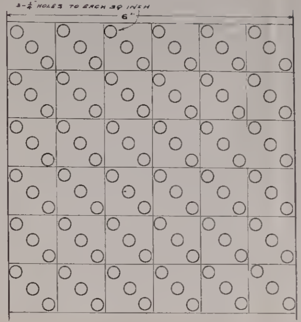

OZONE GENERATOR CELLS SEE DRAWING 207
21'-0"
½" SQ STEEL RODS SPACED 6" CENTERS 26-0 LONG
15" MANHOLE ONE REQD FOR EACH STERILIZER
20" MANHOLE ONE REQD FOR EACH STERILIZER
5'-0"
U TUBE MERCURY COLUMN
2-2
ELEV 23.66
6" TILE PIPE
GLASS
44-⅜ PORCELAIN ENAMEL STEEL TUBES
GLASS
½" SQ RODS SPACED 8" CENTERS
½" RODS
WATER LEVEL
½" SQ RODS SPACED 7" CENTERS 26-0 LONG
8-0
CAST IRON ENAMEL HEAD
GLASS
6-8
16
9'-4
20" TILE PIPE FROM ROUGHING FILTERS
10 SLUICE GATES.
2-10
6-6
9-2
7-2
½" SQ RODS SPACED 8" CENTERS
7-0
15-2
8
6
½" SQ STEEL RODS SPACED 6 CENTERS 2-3" LONG
½" SQ RODS SPACED 6" CENTERS 2'-3" LONG
½" SQ RODS SPACED 7" CENTERS 26-0" LONG
4-4
5-8
WATER LEVEL
6-0
3-2
½" SQ RODS SPACED 6" CENTERS
18-9
½" SQ RODS SPACED 6 CENTERS 26-0" LONG
6 SLOT 6 6" LONG
20
12" PIPE TO CLEAR WELL
PERFORATED
GRAVEL ABOUT THE SIZE OF EGG
2-6
12
15-3
6-0
½" SQ BARS SPACED 7" CENTERS 26-0 LONG
4-6
½" SO STEEL BARS SPACED 10" CENTERS 3-0 LONG
EACH GRAVEL GUTTER PERFORATED AS SHOWN IN PLAN
GRAVEL
½" SQ RODS SPACED 5" CENTERS 26'-0" LONG
A
A
10-0
½" SQ RODS SPACED 6 CENTERS 26'-0" LONG
3'-0"
12
12
12
½" SQ STEEL RODS SPACED 6 CENTERS 18" LONG
10-6

SECTION "C-C"


C
27'-0"
GLASS
B
B
A
NOTE THIS SECTION SAME AS SECTION "A"
6" TILE PIPE 3-REQD FOR EACH STERILIZER
44-⅜ PORCELAIN ENAMEL STEEL TUBES
55-⅜ PORCELAIN ENAMEL STEEL TUBES
74-⅜ PORCELAIN ENAMEL STEEL TUBES
½" SQ STEEL RODS SPACED 6" CENTERS 18'-0 LONG
4 TILE PIPE
½" SQ RODS SPACED 10 CENTERS 5'-0" LONG
10½
17
17
17
10½
½" SQ RODS SPACED 6" CENTERS RODS SAME LENGTH AS IN END WALLS
8
14
14
14
14
8
13
23
23
13
12
12
6-0
6'-0
6-0
6-0
½" SQ STEEL RODS SPACED 6" CENTERS 11'-0" LONG
½" SQ STEEL RODS SPACED 6" CENTERS RODS SAME AS IN WALL ON OPPOSITE SIDE
30'-4
½" SQ STEEL RODS SPACED 6 CENTERS
½" SO STEEL RODS SPACED 6" CENTERS 11'-0 LONG
½" SQ RODS SPACED 10 CENTERS 5'-0" LONG
24-0
½" SQ RODS SPACED 10" CENTERS 10-0 LONG
C

ELEVATION.

3-¼" HOLES TO EACH SQ INCH



PLAN SHOWING PERFORATIONS IN GRAVEL GUTTER
CONCRETE OR IRON ENAMELED

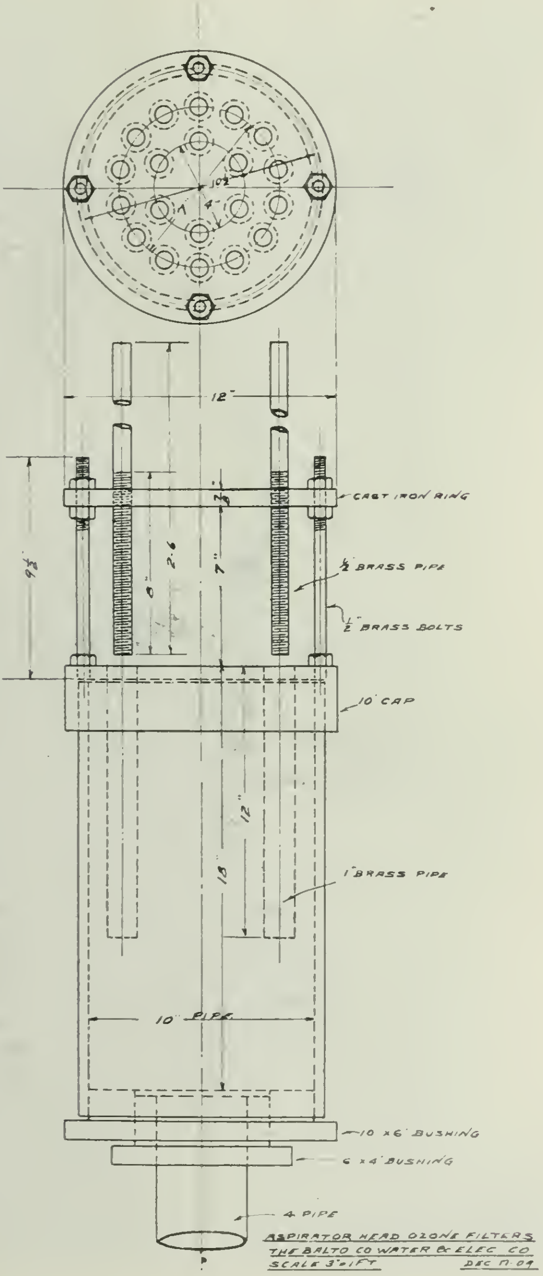
OZONE STERILIZERS

THE BALTIMORE COUNTY WATER AND ELECTRIC CO.

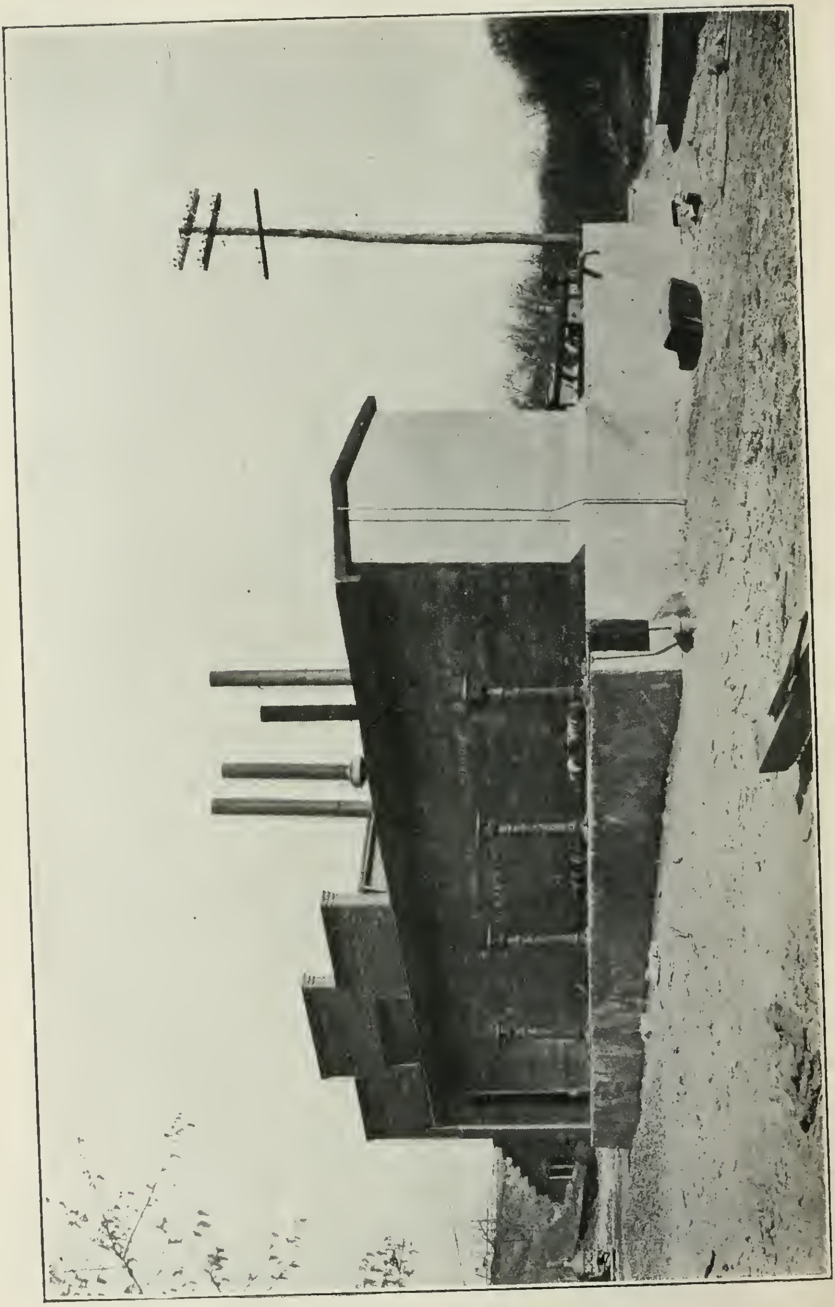
SCALE ⅜ & 12"-1 FT

FEB 11 09.

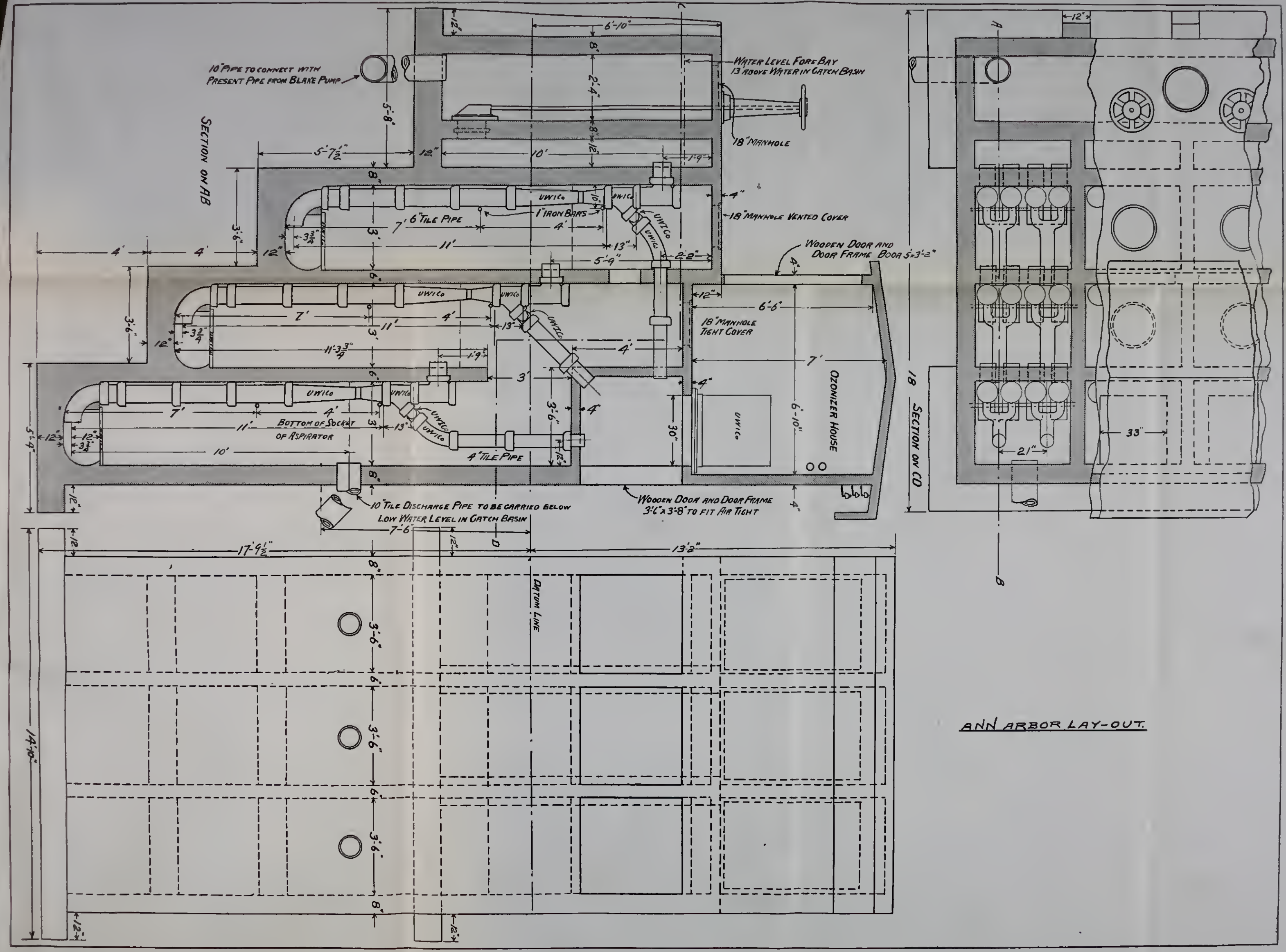
REVISED JUNE 7-09.
" JULY 6-09


10½"
4"
12"
CAST IRON RING
¾"
9¾"
2.6
8"
7"
½ BRASS PIPE
½" BRASS BOLTS
10" CAP
12"
18"
1" BRASS PIPE
10" PIPE
10 x 6" BUSHING
6 x 4" BUSHING
4 PIPE
ASPIRATOR HEAD OZONE FILTERS
THE BALTO CO WATER & ELEC CO
SCALE 3"=1 FT
DEC 17-09

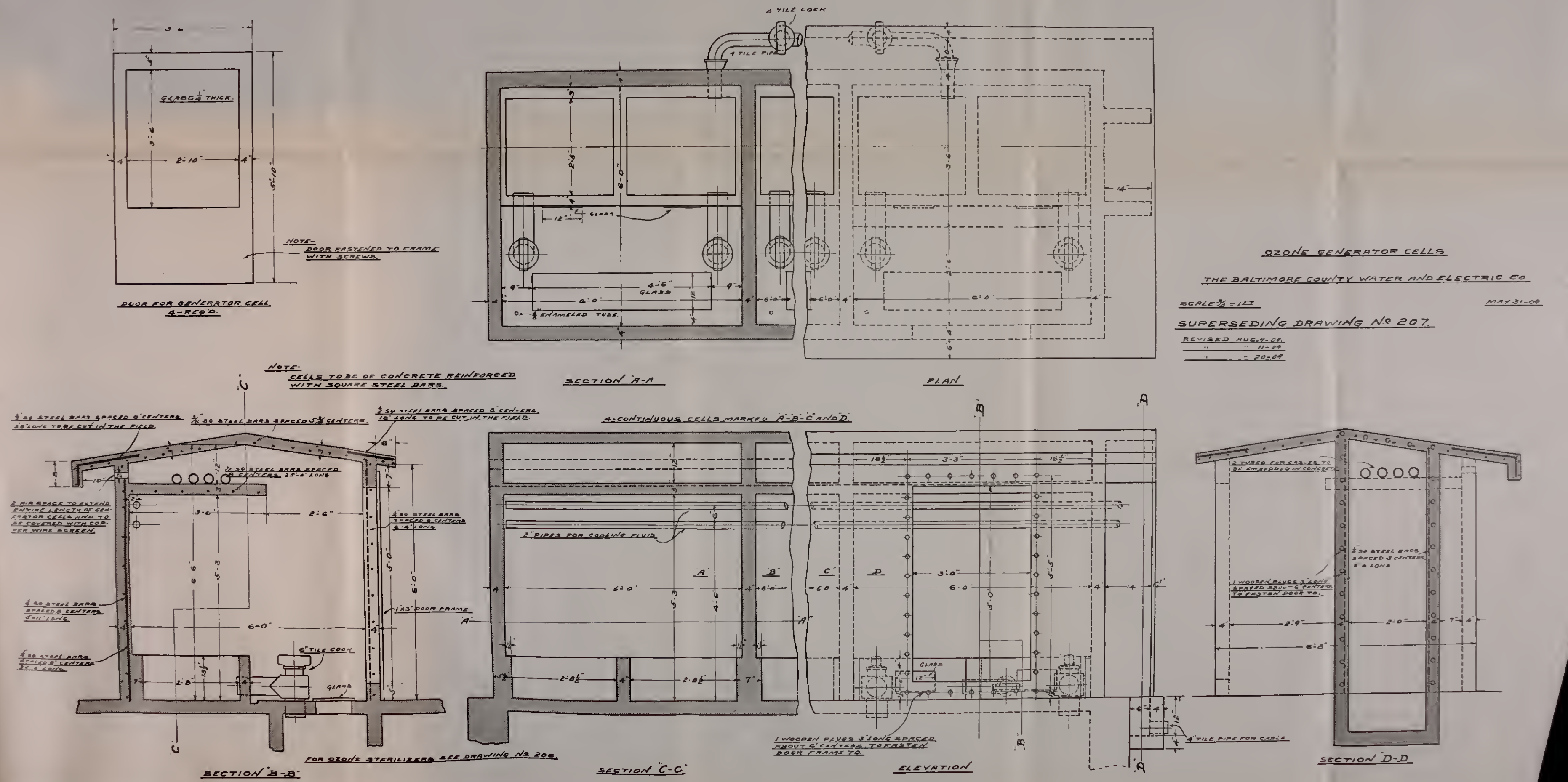
No. 7 B.



No. 8. The Baltimore County Water and Electric Co. Ozone Plant


10" Pipe to connect with Present Pipe from Blake Pump
Section on AB
Water Level Fore Bay 13 above Water in Catch Basin
18" Manhole
18" Manhole Vented Cover
6" Tile Pipe
1" Iron Bars
UWICo
Wooden Door and Door Frame Boor 5'x3'-2"
18" Manhole Tight Cover
Ozonizer House
Bottom of Socket of Aspirator
4" Tile Pipe
10" Tile Discharge Pipe to be carried below Low Water Level in Catch Basin
Wooden Door and Door Frame 3'-6" x 3'-8" to fit Air Tight
Section on CD
Datum Line
A
B
C
D
18
6'-10"
5'-8"
2'-4"
5'-7½"
10'
1'-9"
3'-6"
7'
4'
11'
13"
5'-9"
2'-2"
3¾"
11'-3¾"
6'-6"
30"
5'-4"
7'-6"
17'-9½"
13'-2"
14'-10"
33"
21"
12"
8"
6"
4"

ANN ARBOR LAY-OUT.


OZONE GENERATOR CELLS
THE BALTIMORE COUNTY WATER AND ELECTRIC CO.
SCALE 3/4" = 1 FT
MAY 31-09
SUPERSEDING DRAWING No 207.
REVISED AUG-9-09.
" " 11-09
" " 20-09
DOOR FOR GENERATOR CELL 4-REQ'D.
GLASS 1/4" THICK.
NOTE- DOOR FASTENED TO FRAME WITH SCREWS.
4" TILE COCK
4" TILE PIPE
GLASS
4'-6" GLASS
1/8" ENAMELED TUBE.
SECTION "A-A"
PLAN
NOTE- CELLS TO BE OF CONCRETE REINFORCED WITH SQUARE STEEL BARS.
4-CONTINUOUS CELLS MARKED "A"-"B"-"C" AND "D".
1/2" SQ STEEL BARS SPACED 8" CENTERS 18" LONG TO BE CUT IN THE FIELD.
3/8" SQ STEEL BARS SPACED 5 1/2" CENTERS.
1/2" SQ STEEL BARS SPACED 8" CENTERS, 18" LONG TO BE CUT IN THE FIELD.
1/2" SQ STEEL BARS SPACED 8" CENTERS 25'-4" LONG
2" AIR SPACE TO EXTEND ENTIRE LENGTH OF GENERATOR CELLS AND TO BE COVERED WITH COPPER WIRE SCREEN.
1/2" SQ STEEL BARS SPACED 8" CENTERS 6'-4" LONG
1/2" SQ STEEL BARS SPACED 8" CENTERS 5'-11" LONG
1"x3" DOOR FRAME
1/2" SQ STEEL BARS SPACED 8" CENTERS 2'-4" LONG
6" TILE COCK
GLASS
FOR OZONE STERILIZERS SEE DRAWING No 206.
SECTION "B-B"
2" PIPES FOR COOLING FLUID
"A" "B" "C" "D"
SECTION "C-C"
1 WOODEN PLUGS 3" LONG SPACED ABOUT 6" CENTERS, TO FASTEN DOOR FRAMES TO.
4" TILE PIPE FOR CABLE
ELEVATION
2 TUBES FOR CABLES TO BE EMBEDDED IN CONCRETE
1/2" SQ STEEL BARS SPACED 3" CENTERS 8'-4" LONG
1 WOODEN PLUGS 3" LONG SPACED ABOUT 6" CENTERS TO FASTEN DOOR TO.
SECTION "D-D"

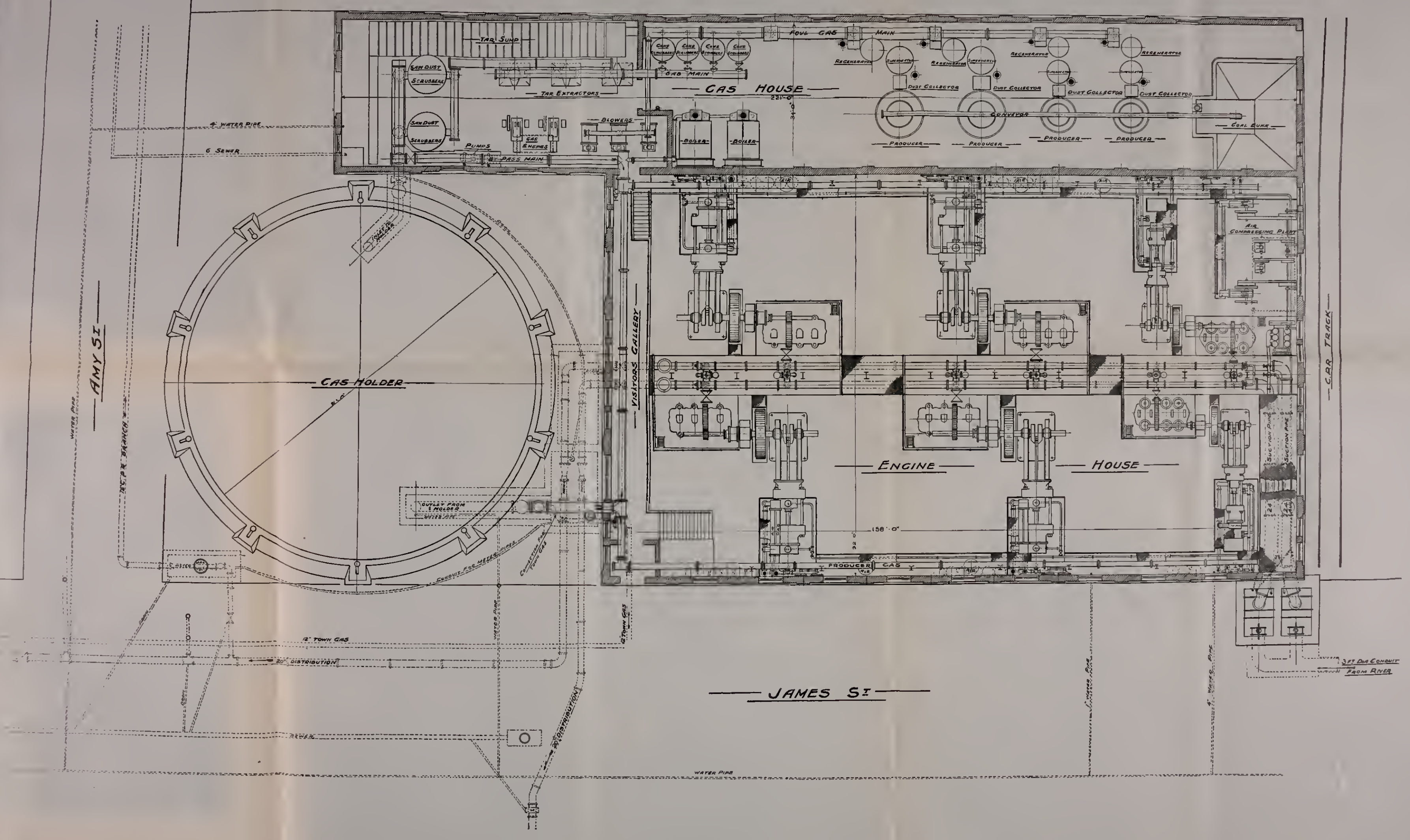
No. 12.

CITY OF WINNIPEG
FIRE SERVICE WATER WORKS

SCALE 8 FEET = ONE INCH

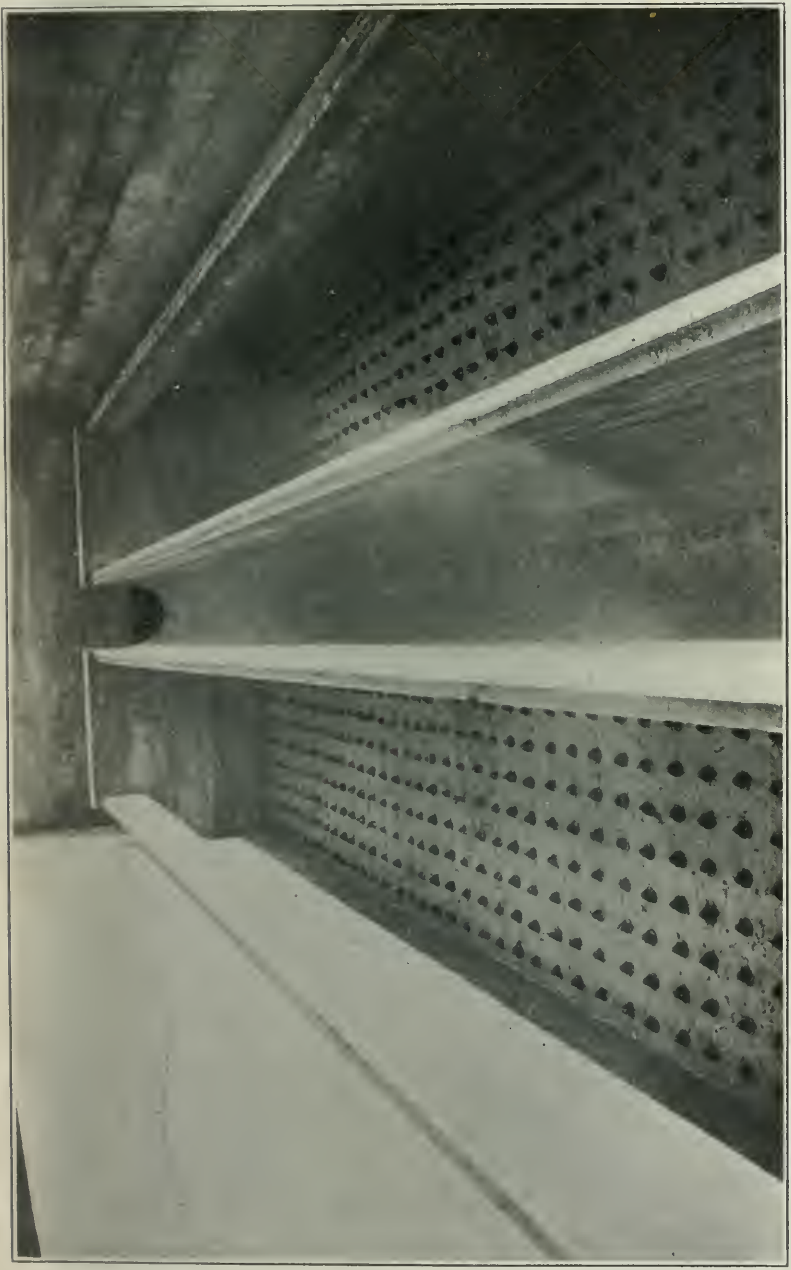
DEC. 11. 1908

N N RUTTAN
City Engineer

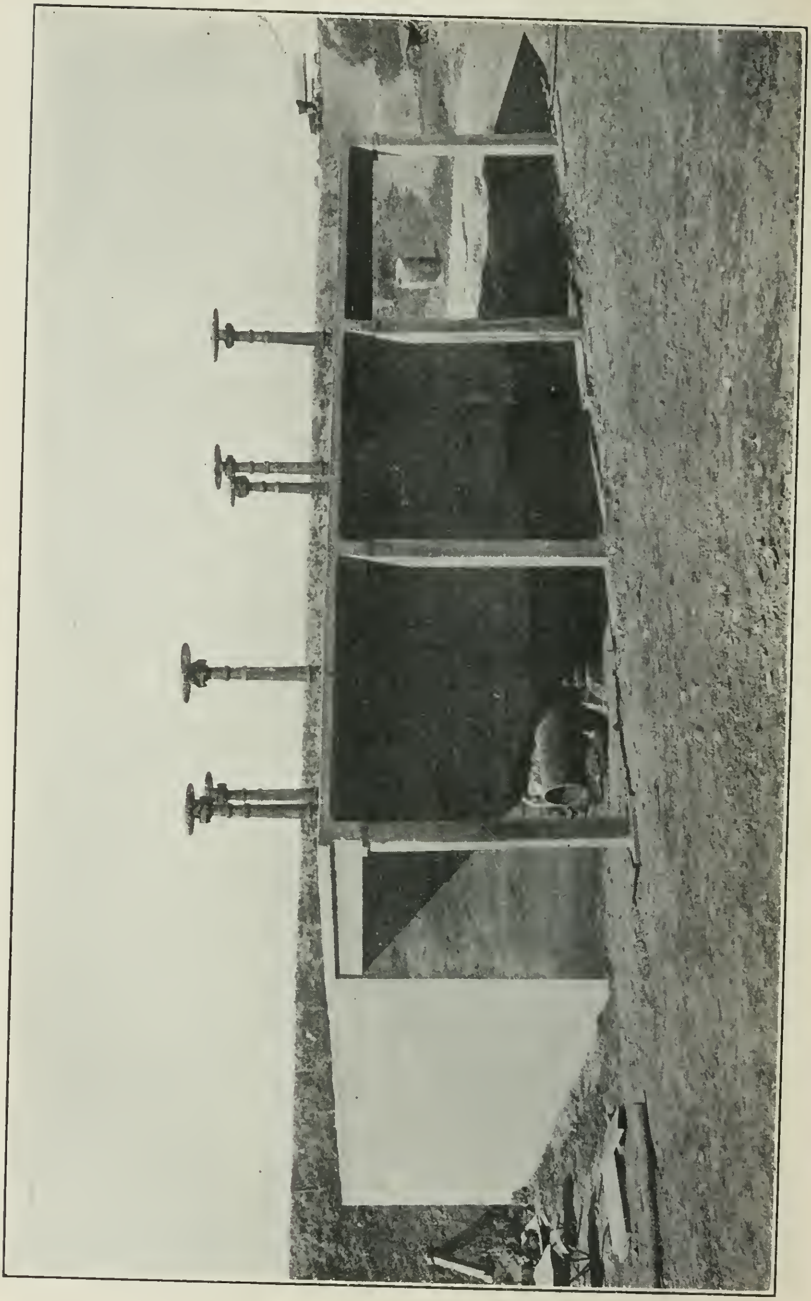


No. 10. The Baltimore County Water and Electric Co. Filter Beds

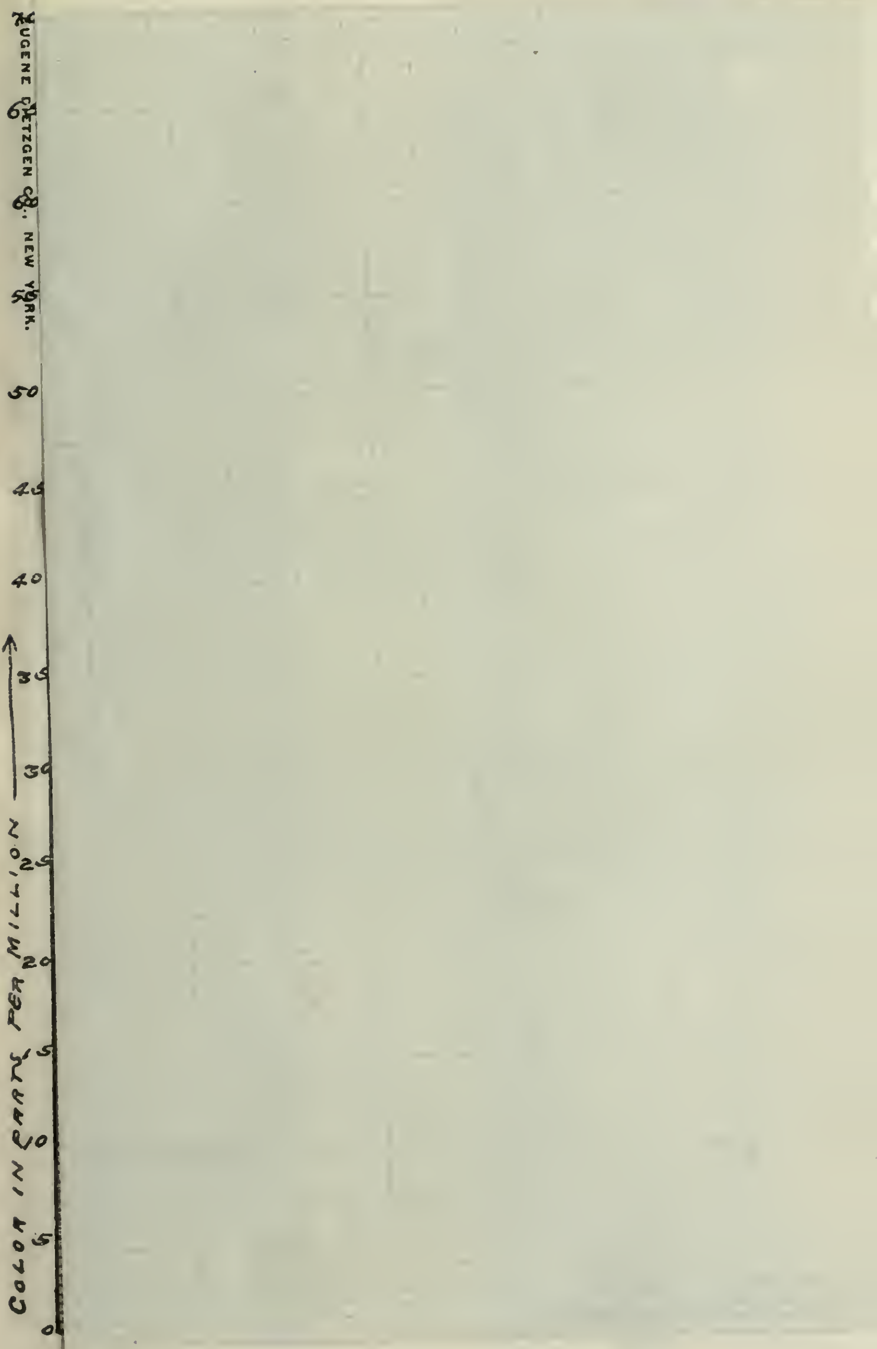
No. 10. The Baltimore County Water and Electric Co. Ozone Plant



No. 11. The Baltimore County Water and Electric Co. Filter Beds



No. 11. The Baltimore County Water and Electric Co. Filter Beds


EUGENE DIETZGEN CO. NEW YORK.
COLOR IN PARTS PER MILLION
0
5
10
15
20
25
30
35
40
45
50

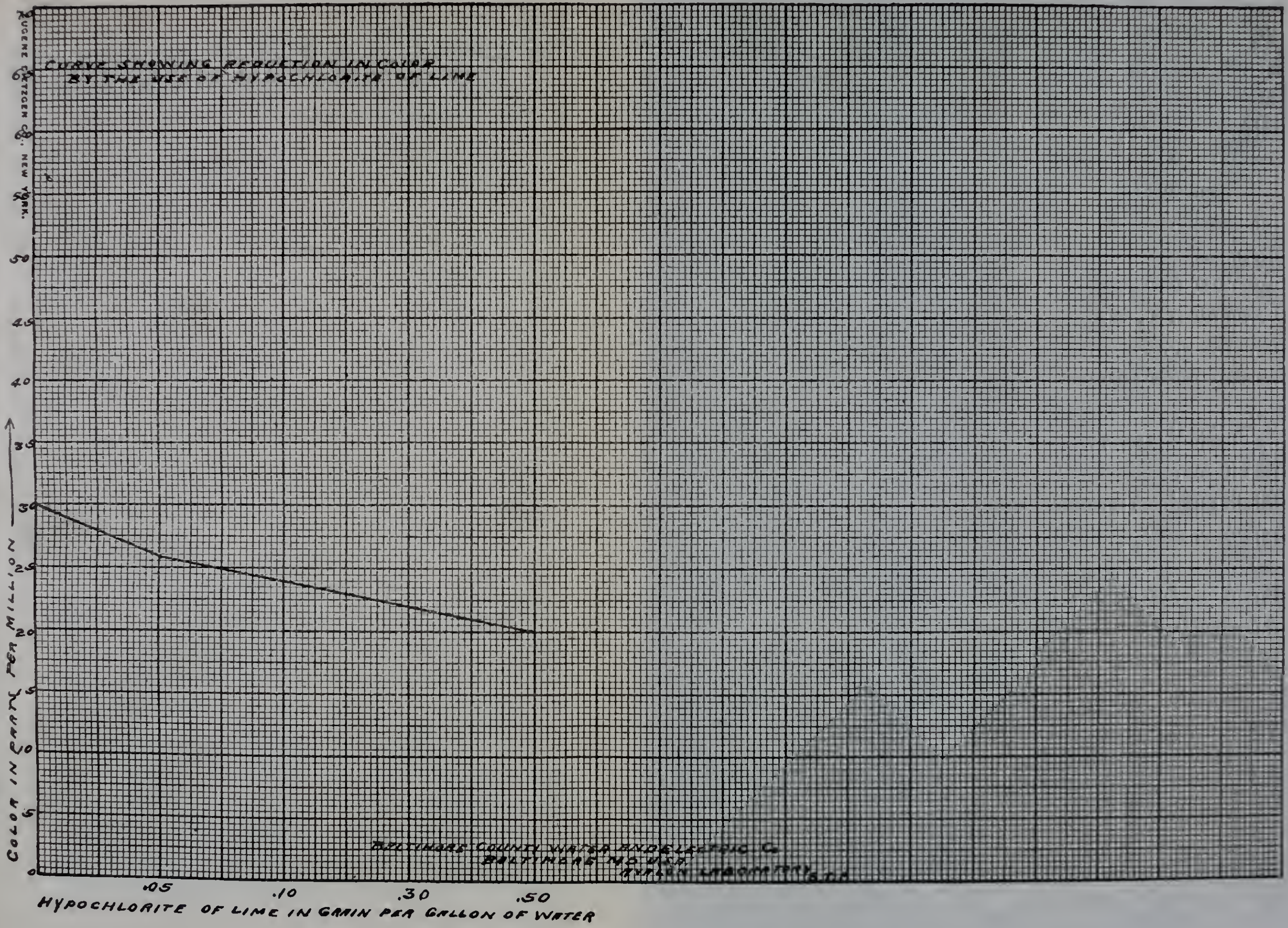


Fig. 14—Curve Showing Reduction in Color by the Use of Hypochlorite of Lime.

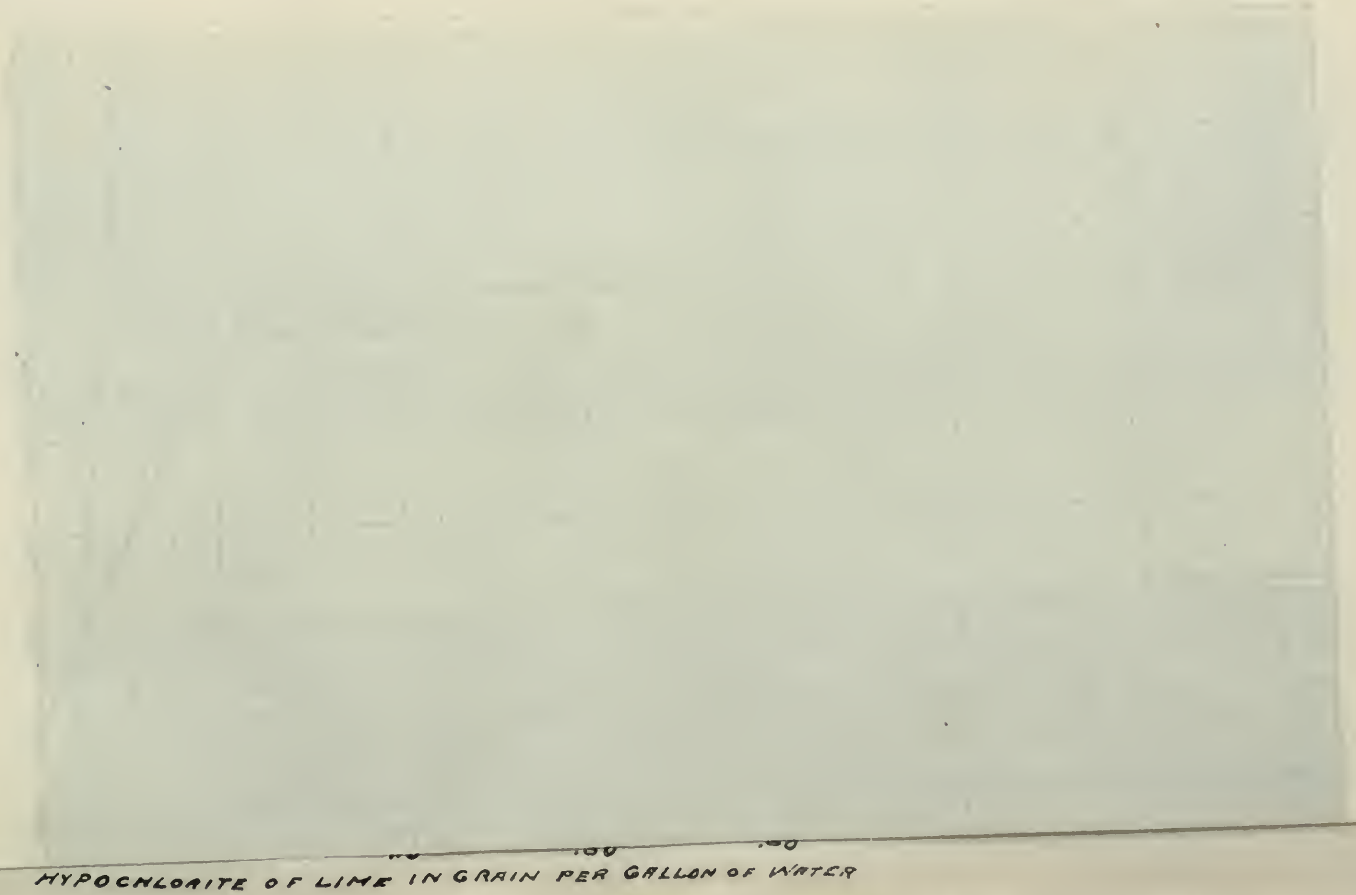


FIG. 15—CURVES SHOWING LOSS OF BACTERIAL EFFICIENCY OF HYPOCHLORITE OF LIME SOLUTION ON STANDING.

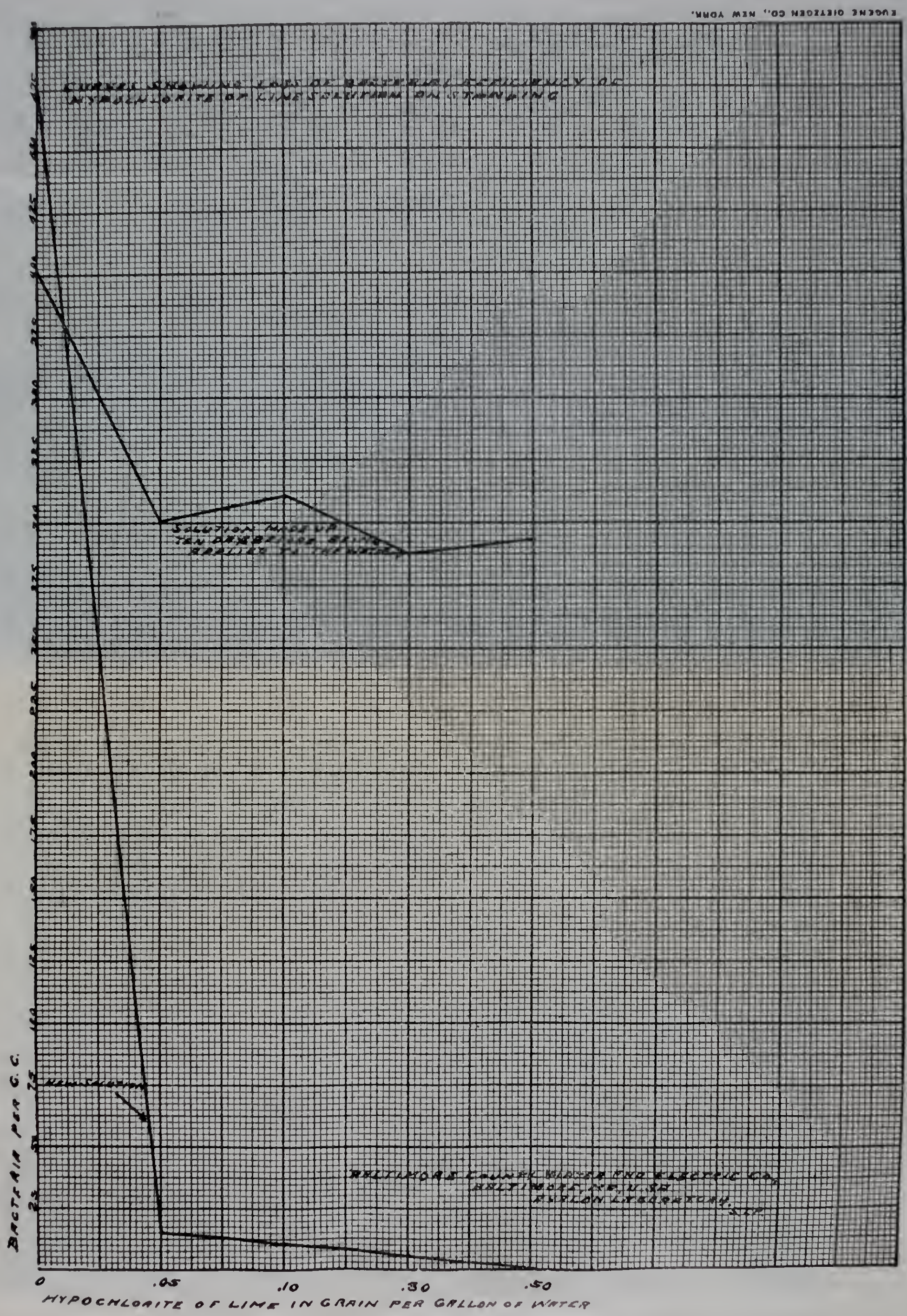


FIG. 15—CURVES SHOWING LOSS OF BACTERIAL EFFICIENCY OF HYPOCHLORITE OF LIME SOLUTION ON STANDING.

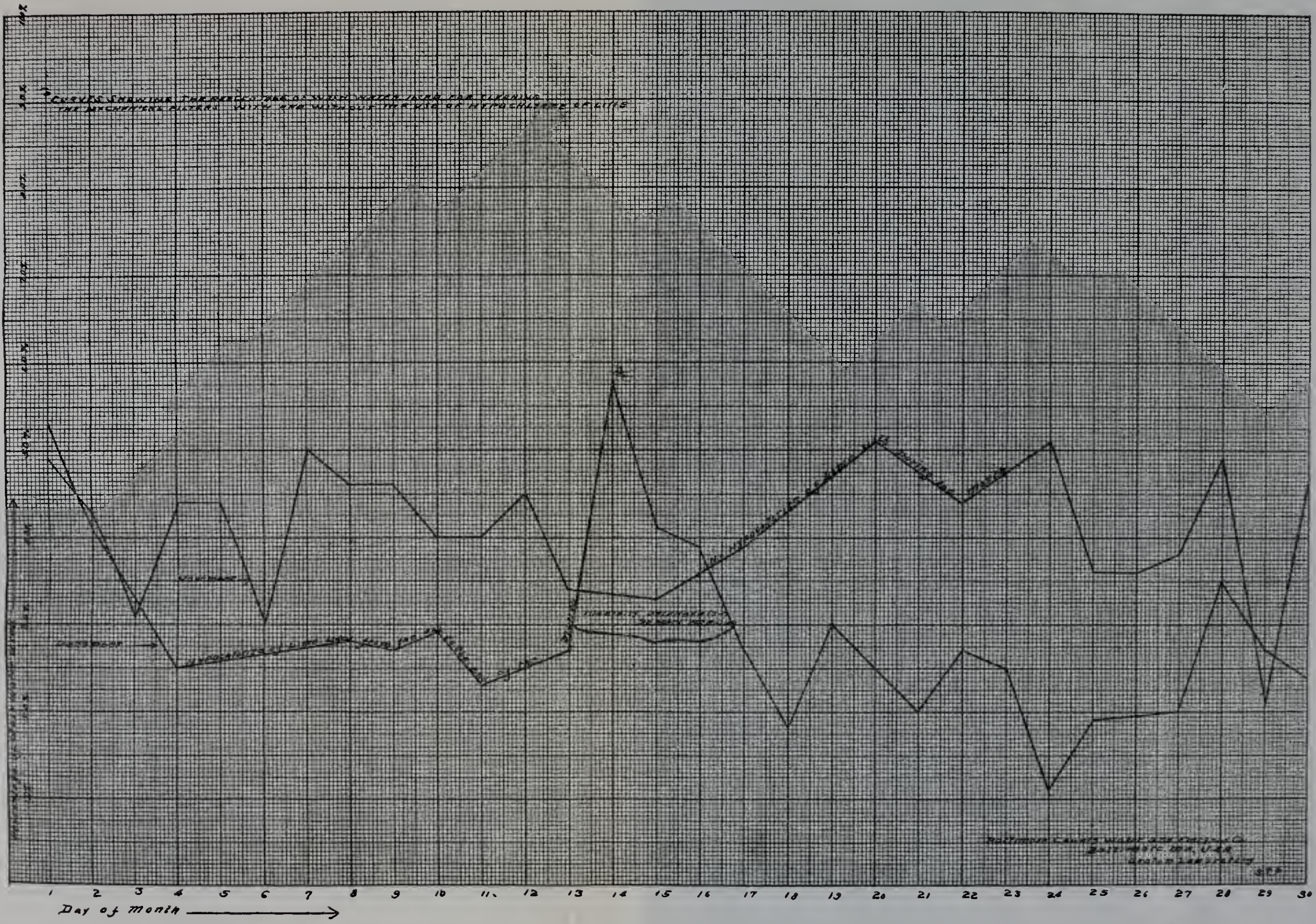


FIG. 17—CURVES SHOWING THE PERCENTAGE OF WASH WATER USED FOR CLEANING THE MECHANICAL FILTERS WITH AND WITHOUT THE USE OF HYPOCHLORITE OF LIME.

FIG. 18—CURVES SHOWING HYPOCHLORITE OF LIME IN GRAINS PER GALLON.

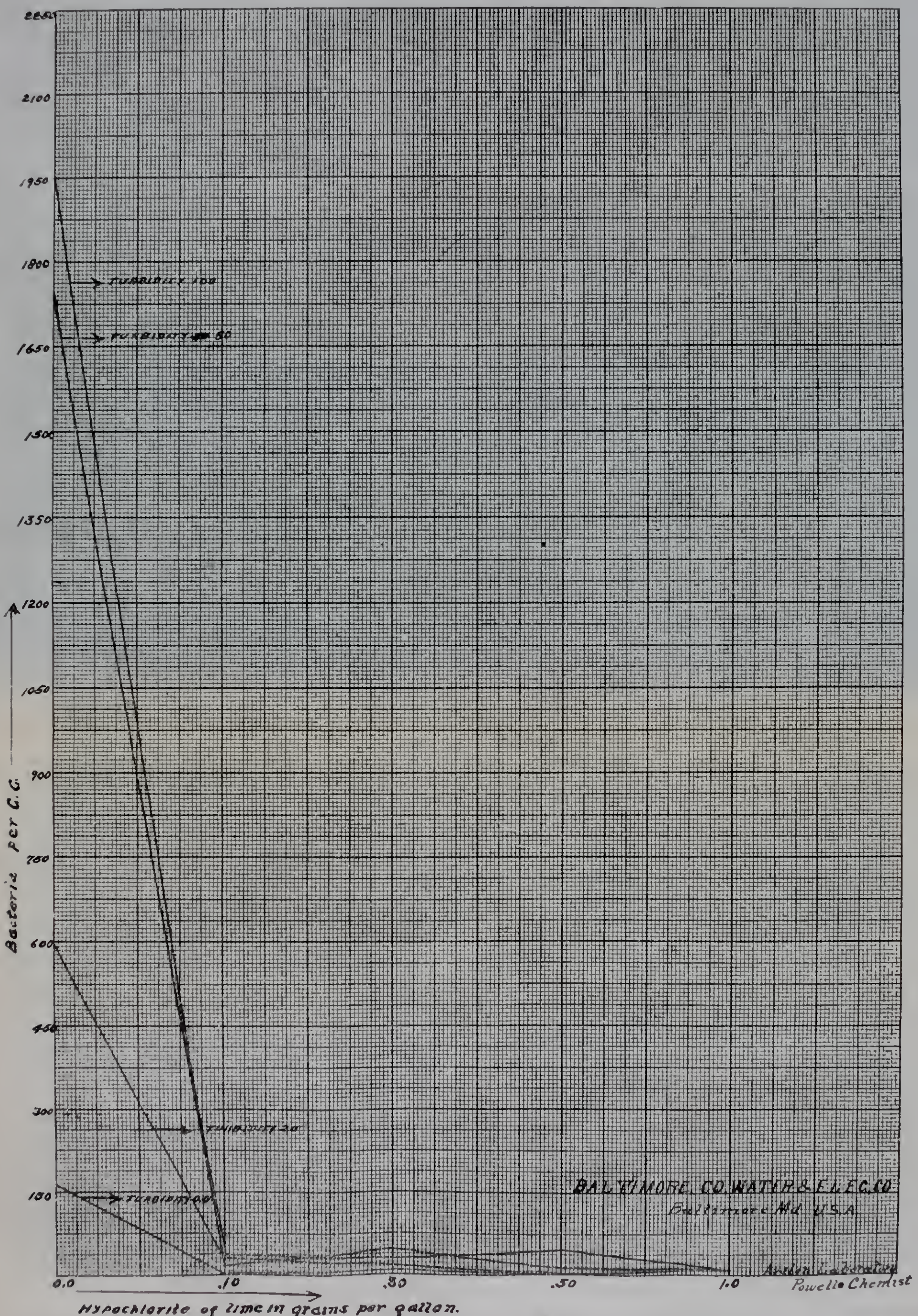


FIG. 18—CURVES SHOWING HYPOCHLORITE OF LIME IN GRAINS PER GALLON.

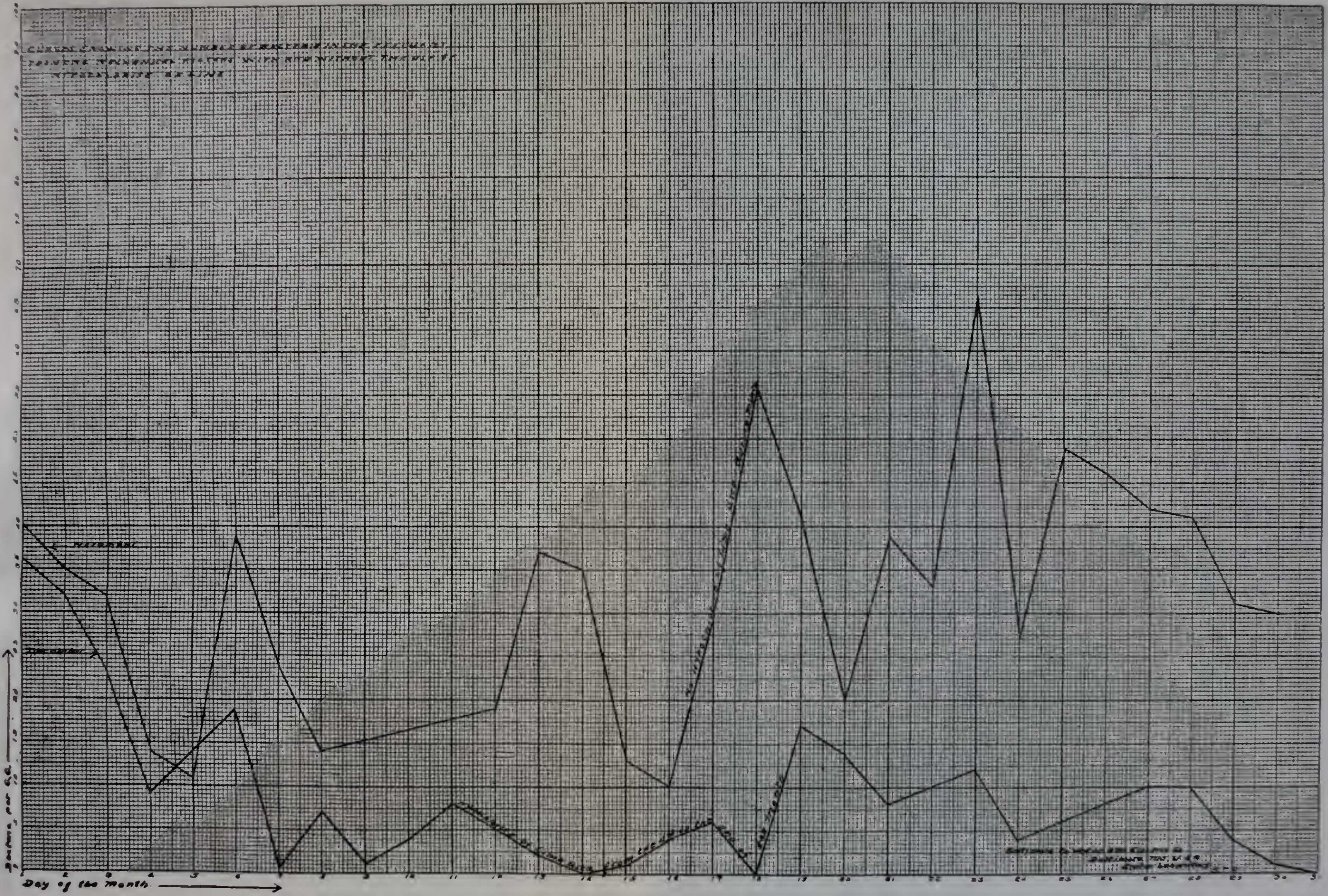


FIG. 19—CURVES SHOWING THE NUMBER OF BACTERIA IN THE ELEMENT FROM THE MECHANICAL FILTERS WITH AND WITHOUT THE USE OF HYPOCHLORITE OF LIME.

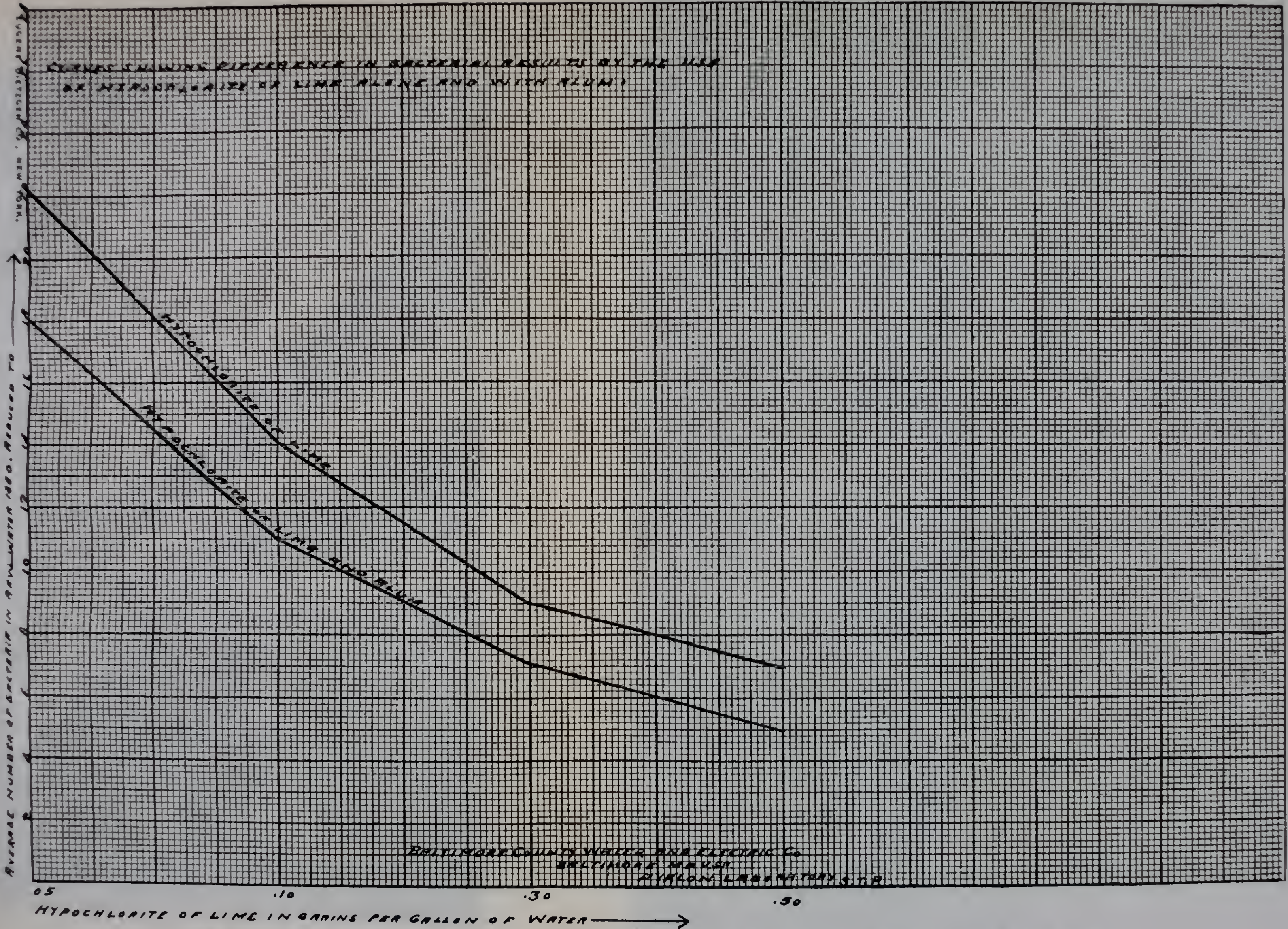
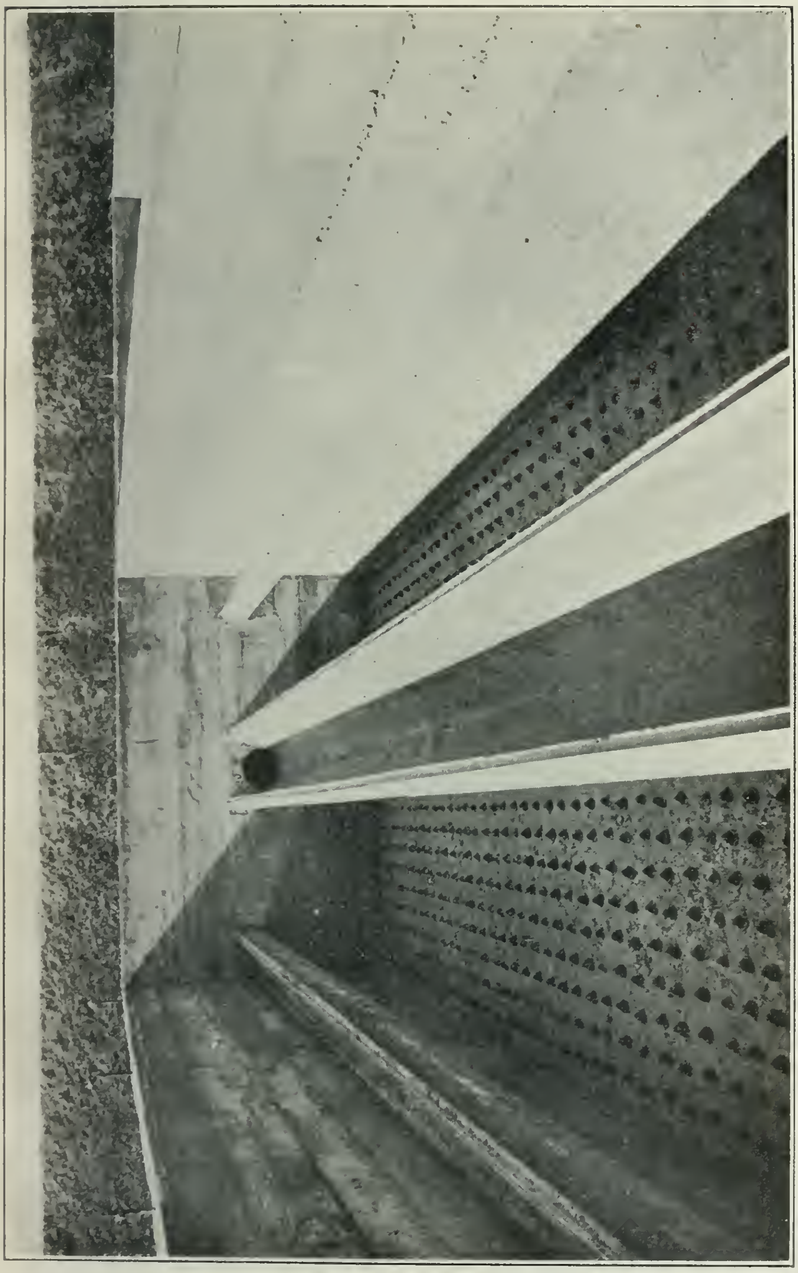


FIG. 20—CURVE SHOWING DIFFERENCE IN BACTERIAL RESULTS BY THE USE OF HYPOCHLORITE OF LIME ALONE AND WITH ALUM.



No. 13. The Baltimore County Water and Electric Co. Strainers in Beds

THE FIRE SERVICE WATER WORKS SYSTEM OF WINNIPEG

LT. COL. N. H. RUTTAN, CITY ENGINEER

In the year 1905, the city of Winnipeg was subject to very excessive fire insurance charges, due largely to the fact that the development of the water works system had not kept pace with the extraordinary growth of the city. As a means of relief, and to place the city in the highest class of fire risks, the city council, backed by the board of trade, had a thorough investigation made of fire fighting water works.

Committees of the council with the city engineer made several visits to the principal cities in the United States and Canada, where special systems were in use, and after a careful consideration, determined that the gas engine pumping plant offered, for the conditions of Winnipeg, the most economical and satisfactory solution of the problem of fire protection.

It was essential, from the fire underwriter's point of view, that any plant adopted should be provided with two independent sources of power. Electricity would have been an ideal power, if the above condition could have been fulfilled. Steam was, on account of the heavy standby losses, out of the question. It may be explained that the pumping station of the domestic water works system is about two miles from the business center of the city, and from the bank of the Red River, from which the water for fire protection was to be obtained. Had it been possible to use the steam plant of the domestic system with additional boiler capacity, it is probable that steam would have been adopted as the motive power.

Steam and electricity being out of the question, gas power, filling all the requirements, was finally adopted. For alternative sources of power, there are available, producer gas and city gas, in addition to a large reserve of producer gas in the holder.

Standby losses in fuel in this system are practically nothing.

The first of the pumping units was placed in service in November, 1907, and has been available for fire protection since that time. The remaining units were completed, and placed in service between that time and the 1st of July, 1908, when the whole plant was practically completed, and its operation taken over by the city.

The distribution is made by eight miles of mains from ten to twenty inches in diameter, and eighty-five fire hydrants. It covers the central, closely built, business section of the city.

PUMPING STATION

The pumping station is situated on the bank of the Red River at the foot of James street, and contains the following equipment:

4 Crossley, 2 cylinder tandem gas engines of 540 h.p. each.
2 Crossley, 2 cylinder tandem gas engines of 250 h.p. each.
Air compressing starting plant in duplicate.
1 Produce gas main supplying all engines.
1 City gas main, in reserve, supplying all engines.

The engines above described drive six triplex double acting pumps.

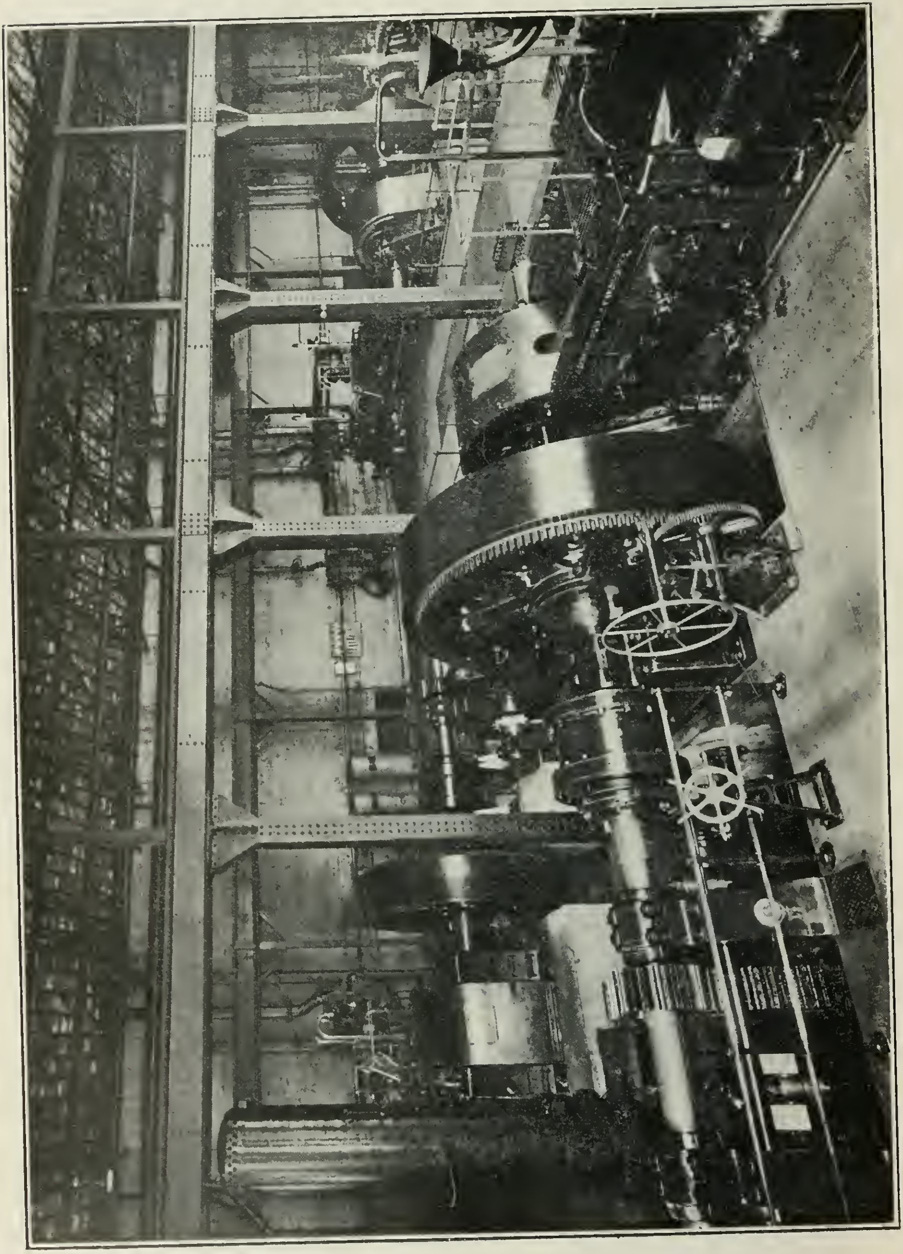
The pumps are furnished with suction and discharge mains, twenty inches in diameter, in duplicate, all pumps being connected with both mains, either main being of sufficient capacity for the whole plant

The pumps take their water from a well, which is divided into two compartments, either of which will supply the whole plant. The water is conducted to the well by an intake pipe three feet in diameter, which extends for a distance of four hundred and twenty-five feet from the well to the deep water in the river, where in ends in a stone ballasted crib.

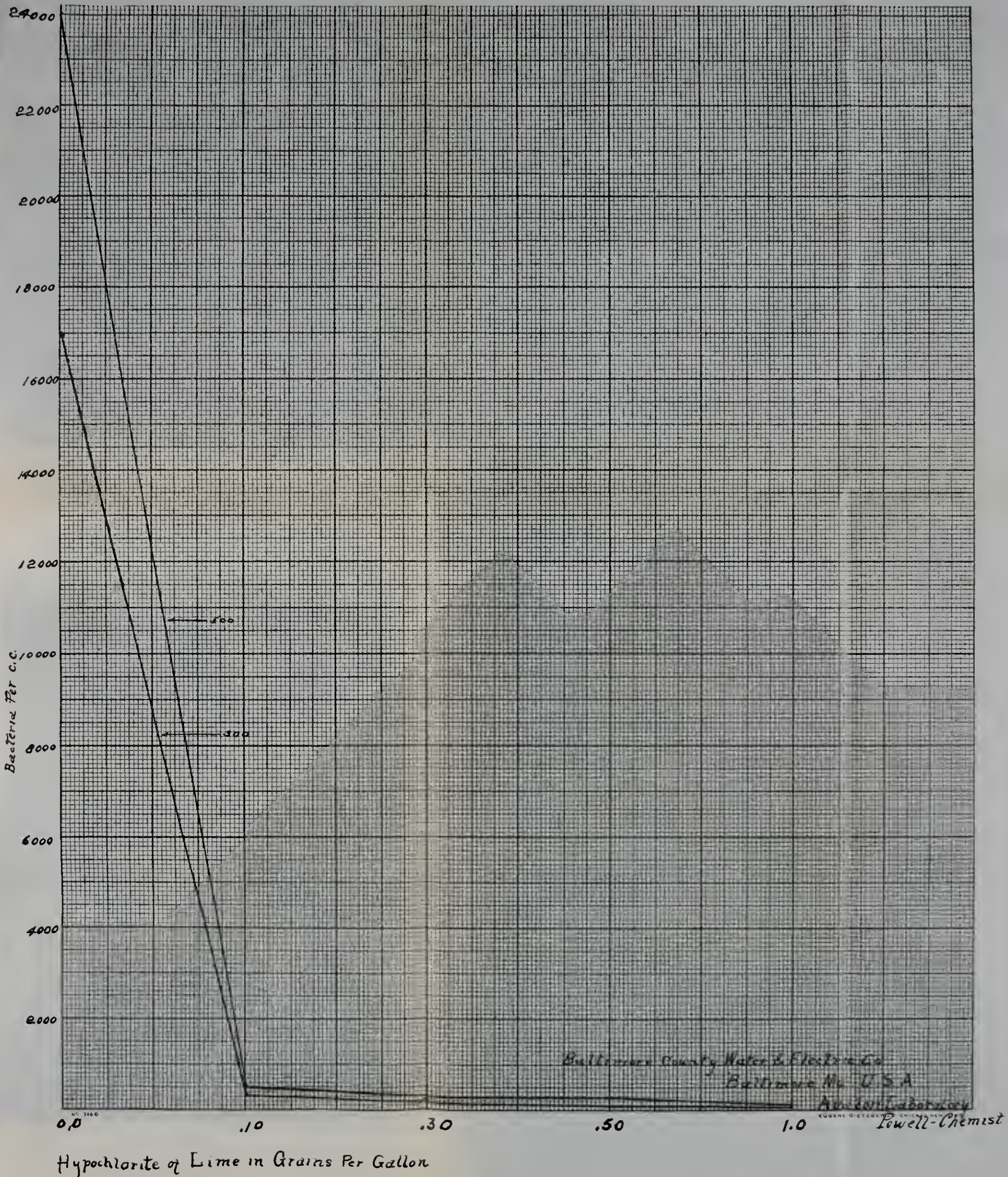
PRODUCER GAS SYSTEM

The gas producer plant may be described as follows:

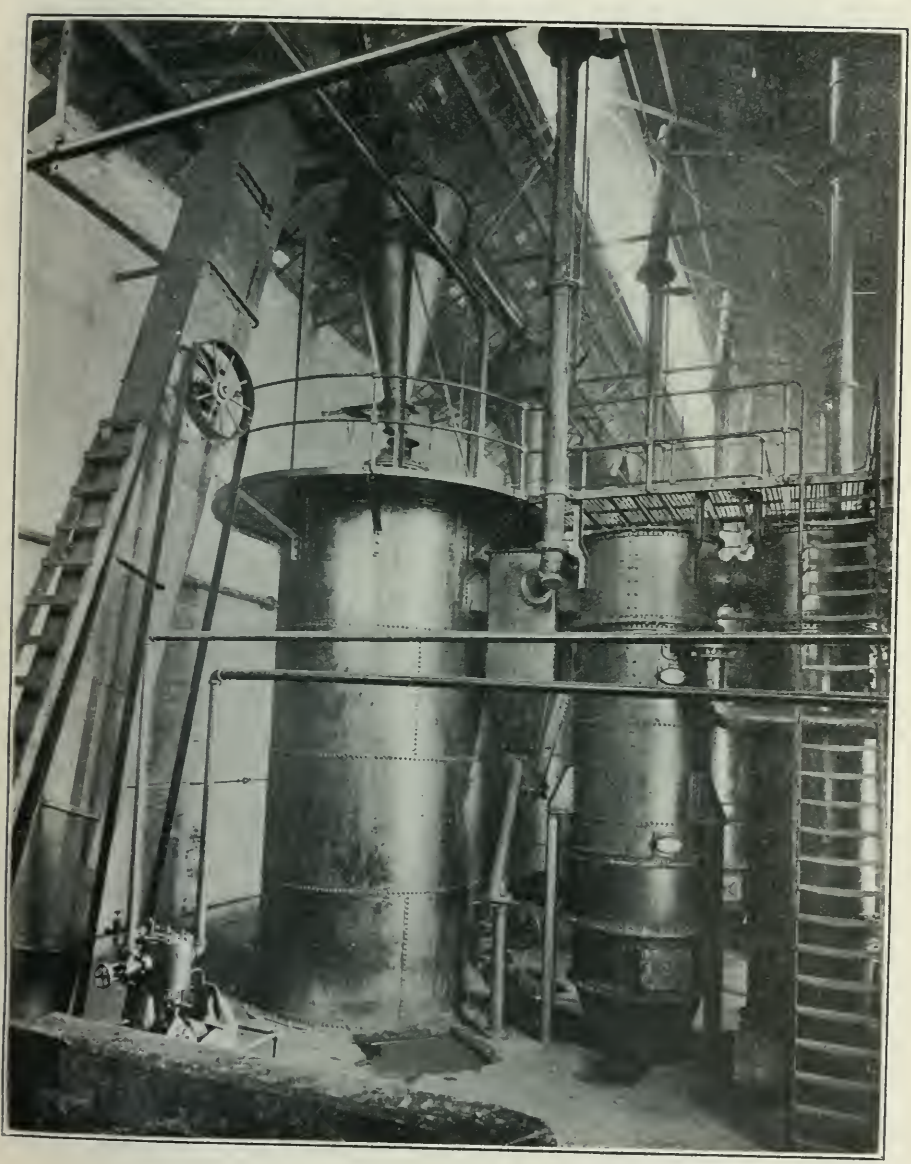
It consists of four Crossley type producers; two of 500 h.p., each eight feet, six inches, in diameter, by eighteen feet in height, and two of 1000 h.p. each eleven feet in diameter by



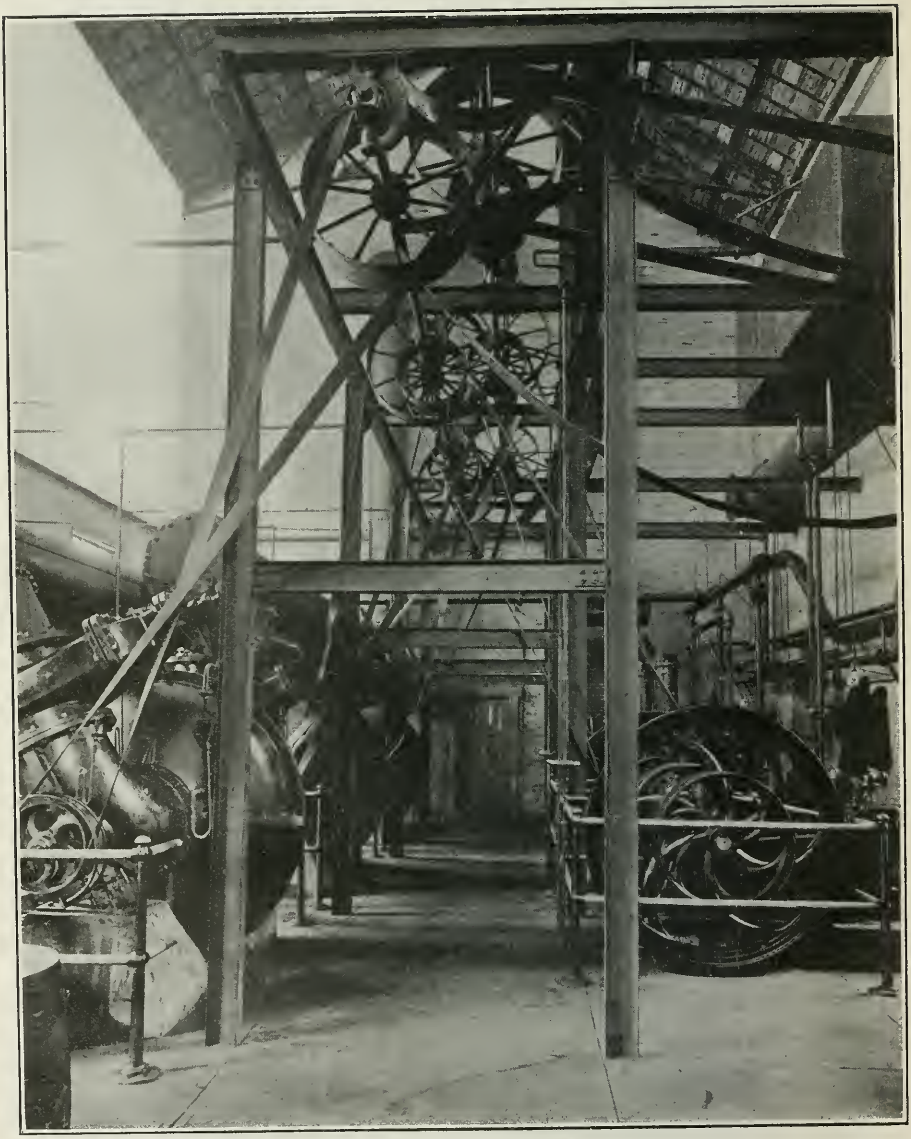
INTERIOR OF PUMPING STATION



THE EFFECT OF HYPOCHLORITE OF LIME WITH HIGH TURBIDITIES



No. 1 Producer



Tar Extractors

eighteen feet in height, with necessary platforms, hoppers and piping.

This plant has an overload capacity of fifty per cent with selected coal, and readily makes gas from anthracite, lignite or any noncaking bituminous coal.

The coal for use in the plant is delivered on track adjoining the building, and unloaded into a hopper having a capacity of one hundred tons.

Elevator and Conveyor

An elevator fitted with a rotary feeding gear to ensure regular feed without choking, raises the coal to a horizontal conveyor placed above the producer hoppers. The elevator and conveyor are operated by an eight h.p. steam engine.

Air Superheaters

Two air superheaters eighteen feet ten inches by five feet three inches, and two eighteen feet ten inches by four feet three inches, with gas and air connections and dust collectors, are attached to the producers.

Hot Gas Boilers

Each unit is supplied with a hot gas tubular boiler.

Wet Scrubbers

Four wet scrubbers, each thirty feet high by five feet in diameter, fitted with tar sieves and filled with coke, remove the condensable hydro carbons from the gas.

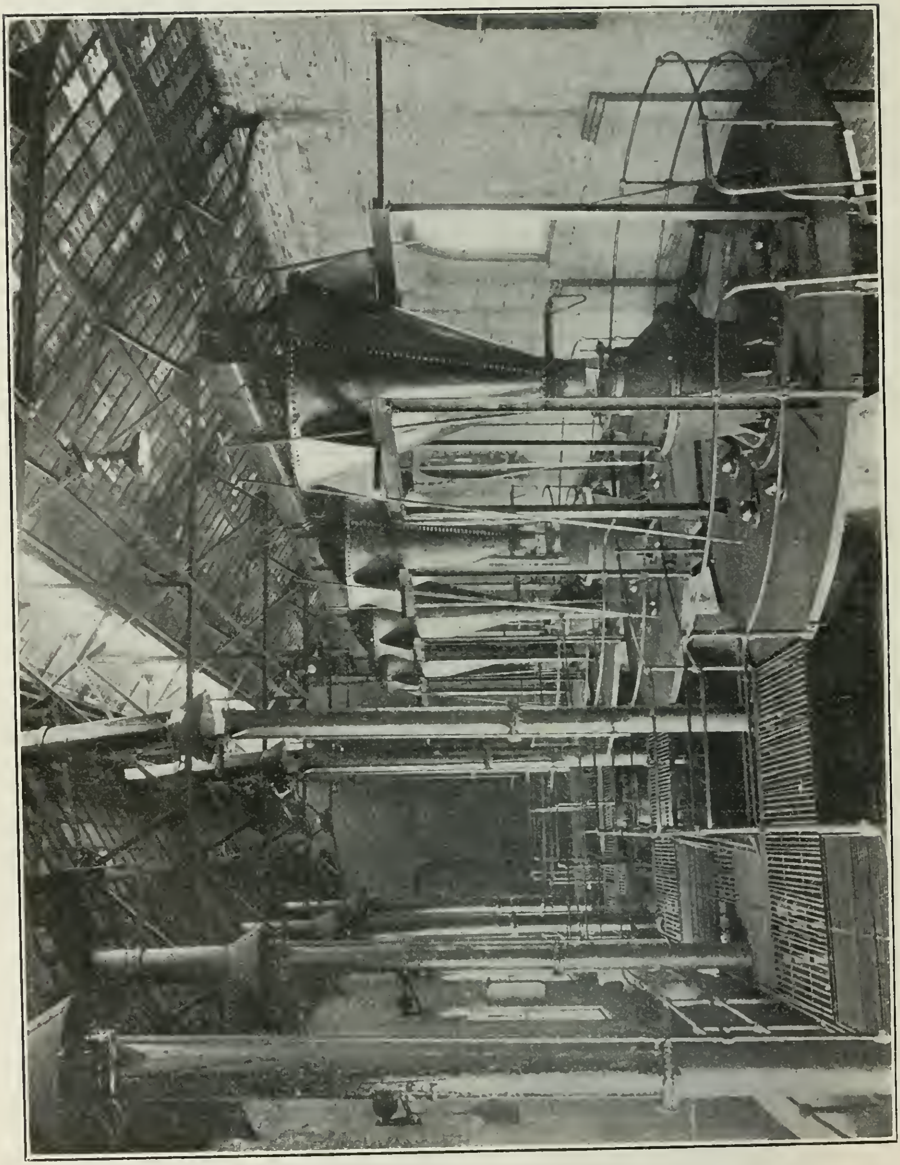
Tar Extractors

Three centrifugal tar extractors five feet in diameter complete the removal of the tar from the gas.

Dry Scrubbers

Two sawdust scrubbers, nine feet by twenty-two feet, either of which is capable of removing any remaining impurities from the gas, are placed near the inlet to the gas holder.

In addition to the above, centrifugal circulating pumps and Root air blowers are provided.



Tops of Producers

The cleaning plant is operated by two eighteen h.p. Crossley type gas engines, either of which is of sufficient capacity to drive the whole plant. The plant is provided with all piping, valves, shafting, pulleys and belting necessary for its operation.

An important feature of the installation is that there is a spare unit of each type of machine, so that in case of a breakdown, the plant can still be operated to its rated capacity.

Two steam boilers, of about fifty h.p. each, furnish what additional steam is required for the producer, and also drive the elevator and blowing engines, and supply steam for heating the buildings.

CITY GAS SYSTEM

The gas holder and pumping station are connected with the city gas mains by a special twelve-inch pipe. If, for any reason, the producer gas system should be out of service, a full supply of city gas may be at once conducted to the holder, or directly to the engines, by a special main provided in the pumping station for that purpose.

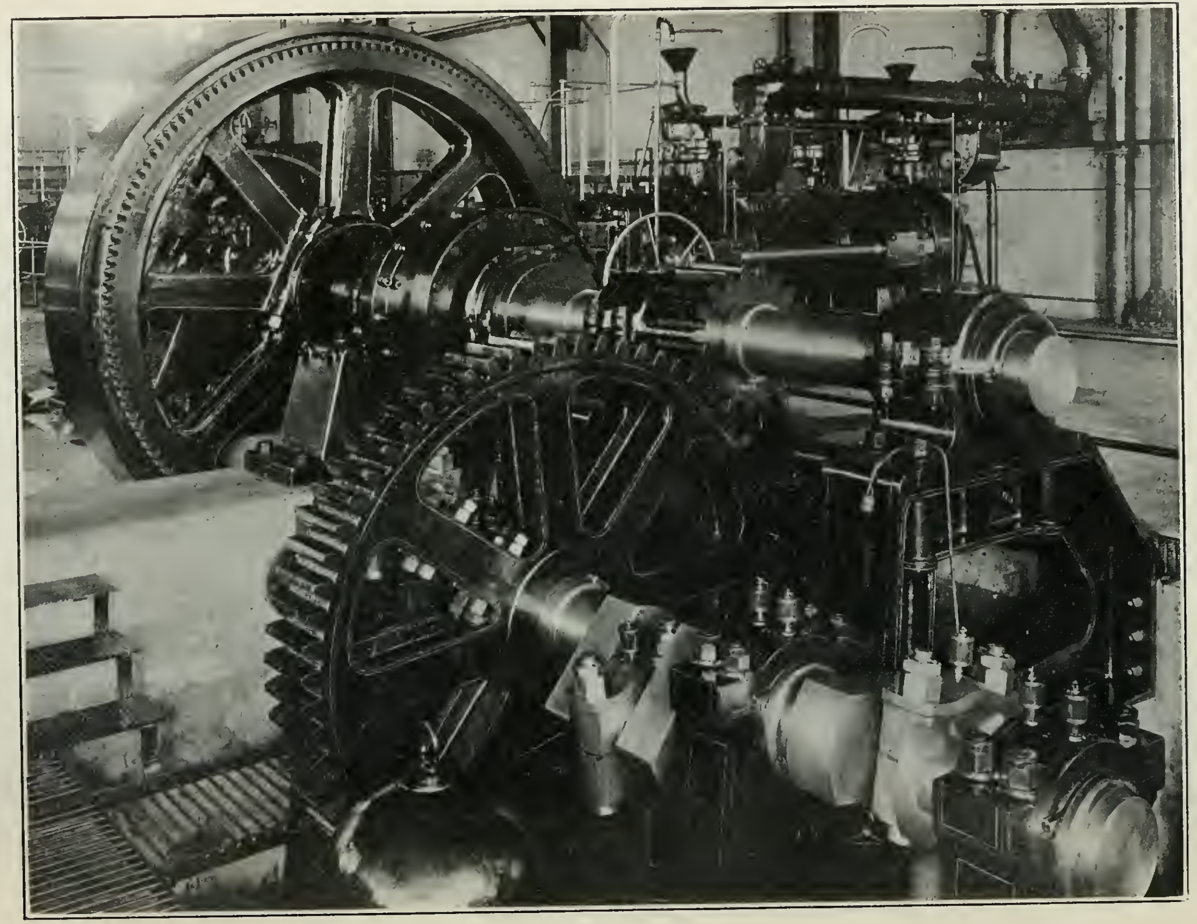
GAS HOLDER

A gas holder of 250,000 cubic feet capacity stores a reserve of gas, either producer or city gas, sufficient to operate the whole plant for from one and one-half to five hours. This will give ample time to fire additional producers, or to make provision for the use of the city gas, in case of a long continued fire. It is not likely that more than half the capacity of the plant will be required except in extraordinary cases.

THE DISTRIBUTION SYSTEM

Two twenty-inch mains lead from the pumping station to Main street by different routes, connecting with submains on the way. Either of these mains, in case of accident to the other, is sufficient to take the water from the pumps when working at their rated capacity.

The mains are designed to withstand the ordinary working pressure of three hundred pounds per square inch, and water hammer. They were tested to 700 pounds per square inch at the foundry, and after being laid, were tested to from five



Pump End

SEVEN $2\frac{1}{4}$ to $2\frac{1}{2}$ INCH STREAMS hundred to seven hundred pounds. The pipes were provided with extra heavy hubs and two lead grooves. These joints have given entire satisfaction.

Hydrants

The hydrants are connected to the mains by eight-inch flanged pipes. They are provided with four four and one-half inch hose nozzles with independent gates. These nozzles are, when required, reduced to three and one-half and two and one-half inches by suitable reducers, three and one-half inches being the largest hose now used.

The hydrant valve is eight inches in diameter, and is provided with one-inch pilot valve to fill the hydrant before opening the main valve against the pressure. Both the valves are operated by the same stem. Each hydrant connection is provided with a gate valve so that the hydrant may be cut out from the system in case of necessity.

THE CONTRACT GUARANTEES

Producer Plant

With bituminous coal of 14,000 B.t.u. per pound the contractors guaranteed to deliver 75 per cent of the heat value of the coal to the engines. Two tests of the producer plant were made, as follows:

Efficiency Test

Bituminous slack coal and coke used in test, B.t.u. per lb. .	11,442
Guarantee 75 per cent of above	8,582
75 per cent of total B.t.u. in coal	226,616,292
Less surplus in holder	625,806
Guarantee	225,990,486
Delivered for use in engines computed on basis of individual tests	199,865,238
Deficiency amounting to 11 per cent	26,125,248

This may be partly accounted for by—

(1) Want of economy in firing boilers.

(2) Leakage from holder which was allowed to blow off between four and five thirty p.m., resulting in a considerable loss of gas.

(3) The coal used was not up to the specification as regards heat value as shown above. It was also of poor quality, on account of the large proportion of dust which it contained.

Working Test

The plant was run from 9:45 a.m. to 5:45 p.m.

From 8:30 to 2:30, producers Nos. 1, 2 and 3 were operated with air inlet valves half open, the pressure on the air main being twenty-two inches of water.

At 2:30 o'clock the gas holder had risen nine feet. At this time, No. 1 producer was cut out, and air valves to Nos. 2 and 3 were opened to full extent, air blast being increased to twenty-five and one-half inches of water.

At 2:30 the calorific value of the gas in the holder was 170.74 B.t.u. per cubic foot.

At 3:30 the holder had lowered one foot three inches, and the calorific value of the gas was 162.13 B.t.u. per cubic foot. The holder was maintained at this level until 4:30 o'clock, the calorific value of the gas at this time being 167.73 B. t.u. per cubic foot.

Between 4:30 and 4:45 there was a rise of nine inches in the holder.

Between 4:45 and 5:30 the holder fell one foot six inches. Ashes were taken from the producers at this stage, and in the final fifteen minutes of the test there was a slight rise in the holder.

The whole plant was operated during this test at a pressure of 300 pounds per square inch.

As the producer plant only was under test, very careful attention was not given to the pumps, and the full delivery of water was not quite reached.

It will be seen from the above that for three and one-fourth hours the full pumping plant was operated on one-half of the producer capacity. The coal used on the test was lignite, a typical analysis of which is included among those given below:

Gas Analysis

	No. 1.	No. 2.	No. 3.
Carbon Dioxide	10.93	9.2	8.2
Oxygen	.50	.4	.2
Carbon Monoxide	16.73	19.0	20.2
Hydrogen	20.60	29.30	19.2
Methane	2.08	......	1.0
Nitrogen	49.16	42.10	51.0
P.c. combustible gas	39.41	48.3	41.4
B.t.u. per foot gas	136.78	150.76	134.16

Coal Analysis

	No. 1.	No. 2.	No. 3.
Moisture	1.5	17.8	1.14
Volatile	24.19	31.55	34.93
Ash	15.74	18.65	11.53
Fixed carbon	58.57	32.00	52.40
Sulphur	2.30	nil	......
B.t.u. per pound	11,280	7,038	11,905

(1) 1st Test—Coal, mixed bituminous slack and gas coke.
(2) 2d Test—Coal, lignite.
(3) Present conditions of operating plant.
Coal, bituminous slack.

PUMPING TESTS

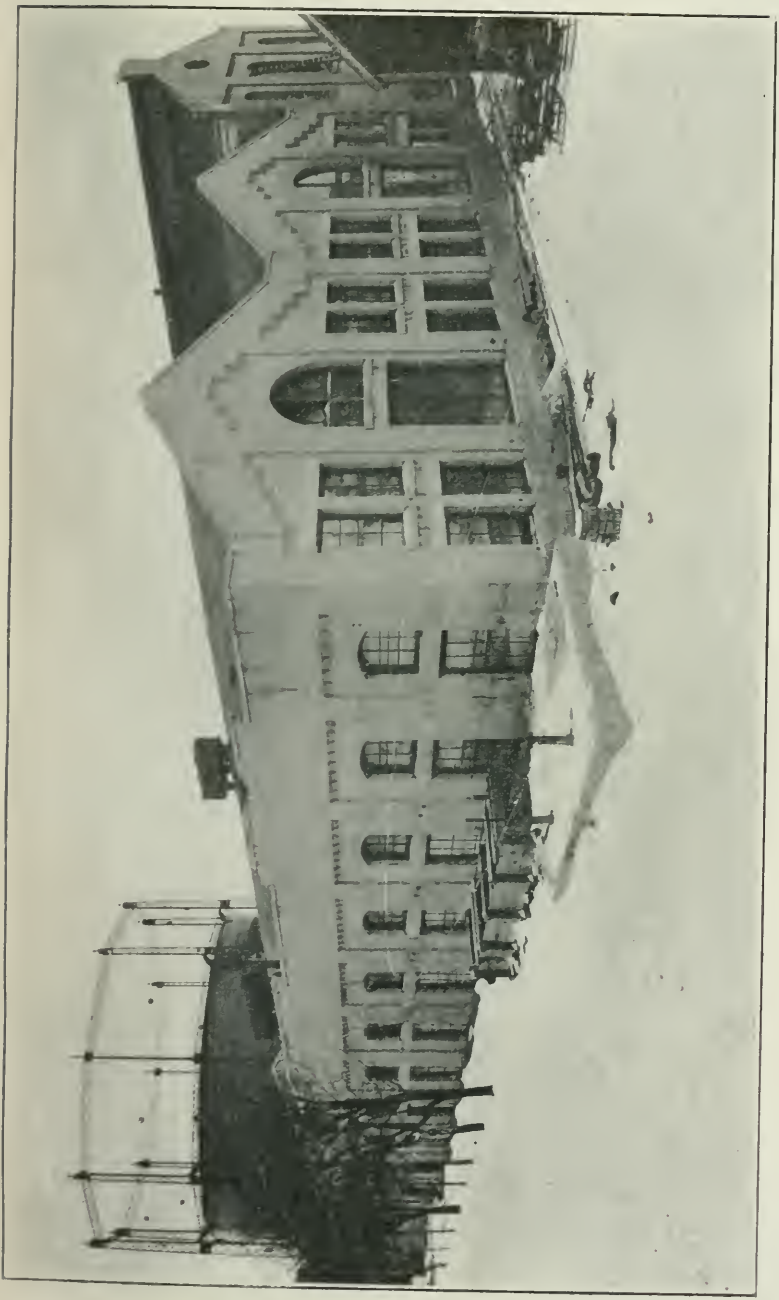
The pumping plant was tested as a whole and by single units.

The guaranteed capacity per twenty-four hours was	12,960,000
The quantity actually pumped	12,047,300
Deficiency (7 per cent)	912,700

In the individual tests all the units largely exceeded the guarantees.

The following are the particulars of the test of No. 5 unit:

Water pumped per minute, gallons	1876.80
Guarantee	1800.00
Pressure on Mains, pounds per square inch	302.88
Guarantee	300.00
Duty in feet pounds per 1,000,000 B.t.u. consumed	174,699,000
Guarantee	162,000,000



BUILDINGS

Mechanical efficiency

Pumping unit per cent	78.40
Engine alone, shop test, per cent	88.40
Engine alone, guarantee, per cent	85.00

The buildings, intake, foundations, and distribution system, were constructed by the city, by day labor, and the cost of the several branches of the work were as follows:

Land	$58,549.80
Buildings: Comprising about 840,000 bricks, 7,500 cubic yards concrete, 15,000 cubic yards excavation, 132 tons structural steel, Roofing, millwork, cranes, heating, etc	179,144.11
Intake from river and well: Excavation, 3500 cubic yards; concrete, 600 cubic yards; Wooden conduit, 425 feet	28,912.80
Machinery, including gas producer plant	396,003.47

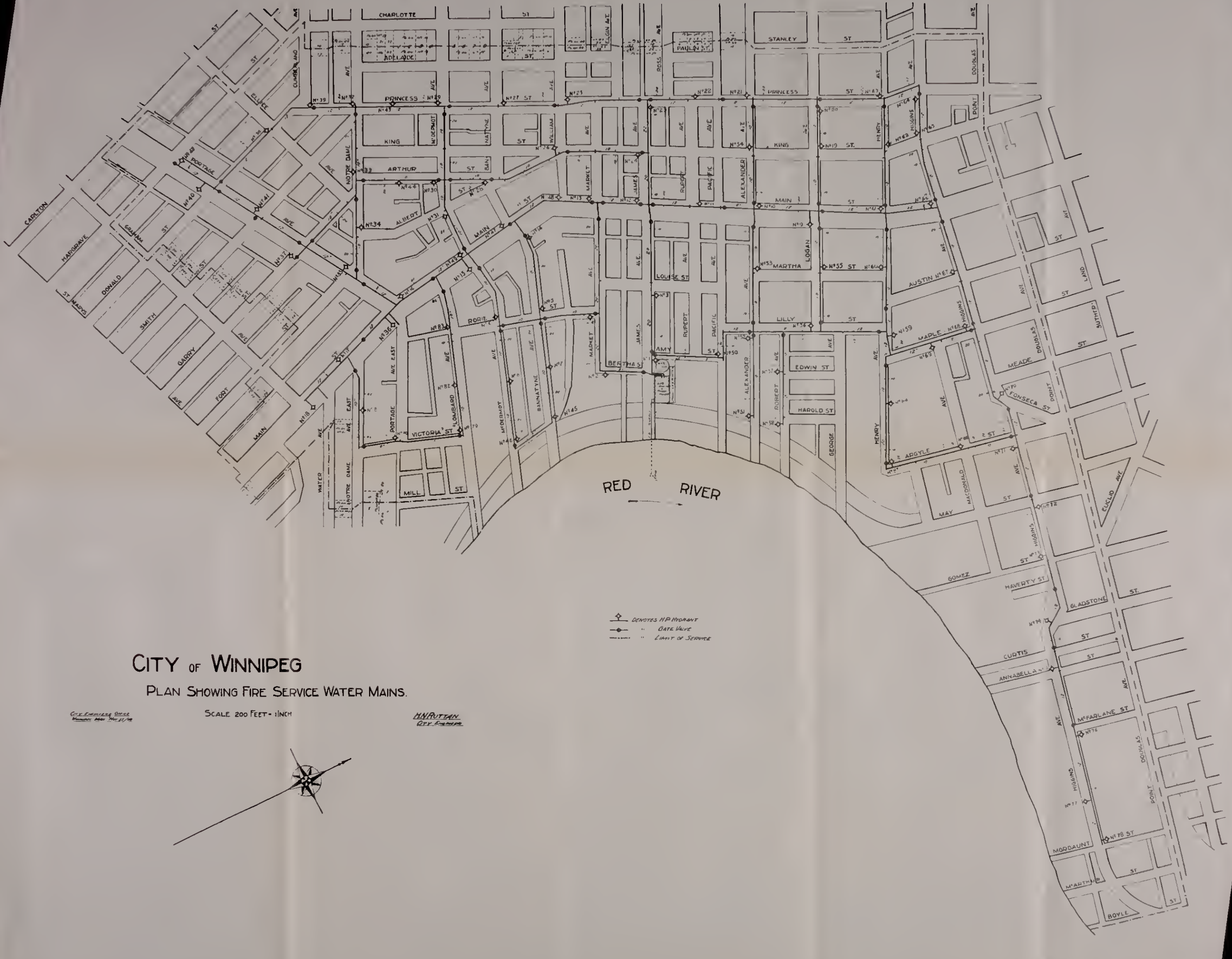
Distribution System

8-inch pipe, 285 feet	$3.00	$855.00	
10-inch pipe, 18,261 feet	3.47	63,366.71	
12-inch pipe, 16,290	4.50	73,307.25	
20-inch pipe, 3,196 feet	9.20	29,403.20	
8-inch flgd., 1,390 feet	8.70	12,093.00	
Asphalt, 13,414 feet	1.30	17,438.46	
8-inch valves, 79	33.00	2,607.00	
Hydrants, 79	200.00	15,800.00	
10-inch valves, 41	45.00	1,845.00	
12-inch valves 26	68.00	1,768.00	
20-inch valves 4	180.00	720.00	
Miscellaneous		6,851.92	226,055.54

Miscellaneous

Preliminary expenses	3,003.57	
Printing, etc	1,405.55	
Tools and plant	325.03	
Spur track	84.48.	
Emergency gas main	3,518.71	
Contingencies	1,174.02	10,311.36
		$898,977.08
Engineering and interest, estimated		44,948.00
Total		$943,925.08

The author wishes to express his indebitedness to his staff of the city engineer's department generally, and to Messrs. S. H. Reynolds, R. D. Willson, H. G. Driskel in particular, for their careful attention to every detail of the work.



CITY OF WINNIPEG

PLAN SHOWING FIRE SERVICE WATER MAINS.

City Engineers Office
Winnipeg Man. [illegible]

SCALE 200 FEET - 1 INCH

H.N. RUTTAN
City Engineer

President Mason: Mr. Wilcox, Meridian, Mississippi, has found a way of dealing with algae and other troubles in his reservoir, and he is going to tell us his method of overcoming the difficulty. It is a topic which is interesting to all of us.

CREOSOTE TREATMENT FOR ALGAE GROWTHS

WILLIAM F. WILCOX

The question that I am to bring before you is one that I present with a little diffidence. I claim no credit for it, neither do I claim that it is a panacea for all evils; but I hope that somebody similarly situated may give it a trial, and that it will prove of as much value in their case as it has in mine. I accidentally discovered that a creosote treatment would keep our reservoir clear of the more common kinds of algae. I was employing the treatment for another purpose. I noticed that creosote on telegraph poles killed the grass, so I poured it in the reservoir trying to kill the grass in there. I found it only killed the algae. The creosote which we used had a specific gravity of 1.06 to 1.07. We introduced it into the intake, the reservoir being an earth reservoir covering twenty-three acres and averaging in depth from eighteen to two feet. The creosote was applied by taking a barrel and putting into it usually one gallon of creosote per acre of surface per application. The creosote is composed of phenol constituents, one of which is carbolic acid; and the different phenol constituents, as I understand it, have different specific gravities. A certain amount of impurity occurs in our commercial creosote. My theory is that when these creosote particles gradually entered the intake of the reservoir where the stream comes in, on striking the water the particles having a heavier specific gravity sink to the bottom, and the different phenol constituents sink in varying proportions, some floating on the surface and some twelve to eighteen inches below the surface. I have found that they entirely destroy the more common kinds of algae, the ones which I understand cause the odor.

We have our water carefully analyzed, and since the treatment with creosote we have been careful to examine it for odor and taste, and have found none. We have also submitted samples of this water to a chemist, and he found no material difference in the chemical constituents. Using one gallon per acre of surface makes it cost fifteen cents per acre per year for treating this water. It has this advantage over sulphate of copper, where it is practical to use it, and that is that creosote is given very commonly in the south for stomach trouble, and is given in doses of from 3 to 5 p. p. m. Our treatment, as you will see, is a little less than .5 p. p. m., so there can be no deleterious effects. If, after treatment at the intake we find any algae along the banks of the reservoir we treat them especially with a little creosote applied with an ordinary sprinkling can, and insofar as we have been able to determine, this treatment entirely removes the trouble.

DISCUSSION

President Mason: Gentlemen, the paper is before you; but before I give you a chance to discuss it I want to say that we have not heard anything about those snakes. I was given to understand that there were a great many snakes to be disposed of. I did walk around that watershed, but if I had known what I heard yesterday I would have made that trip a very short one. I should like very much indeed to have the snake end of it added, and the terrapin.

Mr. W. F. Wilcox: We also had a further trouble with the reservoir which I did not think would be of much interest. In the summer time we were troubled with poisonous snakes, and also with a species of turtle which we call a terrapin, which is especially noxious because of its odor in the summer time. It has practically the habits of a hog. These terrapin lay all along the bottom of the reservoir and make the water turbid. They also at times give the water a little odor, especially if they happen to accumulate at the outlet of the reservoir. Now, that part of the creosote which is of lighter specific gravity and remains on the surface of the water is very objectionable to any animal which feeds on the surface or comes to the surface for air, as the terrapin or the alligator does. We found, therefore, that the creosote treatment enabled us to be rid entirely of the terrapin.

Mr. E. E. Davis: I was in hopes that I would have a chance to ask Mr. Wilcox a question along lines pertaining to snakes. I would like to ask him his experience with reference to eels. In Richmond we are troubled very much with eels. I have known the turbine wheels to be clogged and stopped by a conglomerated school of eels. We have experienced a great deal of trouble from the taps becoming stopped by ells, and we have never found anything that would get rid of them. I remember in one case our man had to cut the pipe in two in order to get the eel out. It had become very much decomposed, and when the gentleman who made the complaint to us saw that eel he said, "Has that thing been in my service a long time?" Our man said, "Yes, I judge it has been in there about a week." The gentleman said, "I thought my coffee tasted mighty greasy."

Mr. W. F. Wilcox I will answer Mr. Davis's question: The eels that we have are commonly called Lombard eels. We have had no trouble with them. We have entirely eradicated the snakes with this creosote treatment, which we have used for about three years. The snakes, terrapin and all reptiles removed their habitat from our water.

Mr. M. R. Sherrerd: I would like to ask the gentleman if he made any attempt to spread the creosote through the water further than eighteen inches by agitating the water, or was it necessary to do that?

Mr. W. F. Wilcox: No, we did not find it necessary to do that.

Mr. Dabney H. Maury: Is the water subsequently purified or filtered in any way, and is there any taste left in the water?

Mr. W. F. Wilcox: After the water comes from our impounding reservoir and goes into the settling basin, as it enters the settling basin it is treated with sulphate of aluminum. After traveling three hundred feet through this settling basin it goes through mechanical filters and from them into the clear water basin. It is then pumped to the distribution system. We have an analysis made at regular intervals. We are very careful about the analysis, as the people in our town think they are all born chemists, and a Mississippi judge ruled that any man knew as much about water as Dr. Mason, and was as much capable of passing an opinion upon it.

Mr. A. H. Wehr: We had considerable trouble in one of our filtered water reservoirs last summer with pollywogs which developed into frogs. The little fellows got into the screens of our intake and from there all through the system. Though our water was clean, every once in a while somebody would draw a little pollywog into his glass of drinking water or bathtub. We would assure him, of course, that if a pollywog could exist in the water it was good water for the consumer to use. However, we tried copper sulphate in small doses, and they seemed to thrive on it; it seemed to increase their number. The only thing we could do was to enlarge our intake and add on to the end of it a brass screen, and in that way we got the openings small enough to prevent pollywogs from getting in.

Mr. Stuart Wood: Did you try putting in fish to eat the pollywogs?

Mr. A. H. Wehr: We have fish in the reservoir, but they did not phase those pollywogs.

Mr. Leslie C. Smith: I would like to ask whether the treatment with creosote for algae was continuous, or how long the algae season is during the year in your reservoir?

Mr. W. F. Wilcox: The treatment is applied in the early spring, but one treatment, one gallon per acre. If during the season we see any growth of algae along the banks we spray them with small sprinkling cans.

Mr. John W. Alvord: The delectable subject of snakes and terrapin recalls to my mind an examination I made of a reservoir in a city in Eastern Tennessee not long ago. There, they showed me a small mesh wire fence about eighteen inches high running around the outside of the reservoir. As I had never seen anything of that kind before I was curious enough to ask them what it was for. They informed me that it was a "frog fence," that the frogs in that vicinity had a habit in the evenings of meeting together and discussing going value and flat rates, and then taking a swim in the reservoir; so this fence had to be built to prevent the exhibition of any such interest in the water question as was there displayed. I give you this story for what it is worth. It is just possible that being from up North I was cruelly imposed upon, as I sometimes am; but that was the tale as it was told to me.

MR. STUART WOOD: I saw a reservoir a number of years ago, in Georgia, of about two million gallon capacity, where they had built a fence to keep out not frogs, but hop-toads. Perhaps Mr. Wehr's reservoir was of larger extent, and he may have had more vegetable matter and more pollywogs.

MR. J. M. DIVEN: It is a great surprise to hear a man of Mr. Alvord's large experience in water works affairs speak as he does of an ordinary toad or frog fence. The construction of such a fence was the first work the speaker ever had charge of in connection with a water works plant, and he supposed it to be a very common thing. This fence was not constructed in the south, but in the state of New York. The clear water reservoir of the plant, in the south, with which he is now connected has such a fence, and seems to have need of it; for any break in the fence means frogs in the reservoir.

The fence first mentioned, in the north, was built in about 1870, and was around a small distributing reservoir—capacity 2,500,000 gallons. It consisted of two twelve-inch boards set on edge one above the other and held in place by stakes driven in the reservoir bank—which was of earth. The bottom board was let into the ground about three inches, to prevent the toads and frogs from burrowing under it. It was later found necessary to pack along the boards with coarse cinders, as the frogs would dig under the fence in the soft dirt. This fence is still maintained.

The fence was erected because the entire water supply was cut off from the city by the accumulation of frog spawn on the outlet screens. It being a very dry season and their usual spawning puddles dry they came to this reservoir by thousands.

A RAILWAY EPISODE

WILLIS B. DURLIN

The Lake Shore and Michigan Southern Railway runs through the center of our city, and there are about sixteen grade crossings where our mains lie under from four to fifteen or more tracks. Up to five or six years ago when we wanted to do any work under the tracks we did it without consulting anybody, our own men looking after the supporting of the tracks over the trench. Within the last decade, however, there has been such a wonderful increase in the weight of locomotives and cars, as well as in the number and speed of trains, that I presume the railroad people became afraid of accidents resulting from that method. At all events they requested us to notify them whenever any work was to be done under their tracks, so that they might do the supporting work themselves, since which time they have been doing all of that work, and in a much more elaborate manner than we should have thought necessary. That was all very fine, but after a while they began sending us bills for the work, which we promptly returned, refusing payment. This went on for two or three years until finally they requested a hearing on the subject, which we of course granted. So, an appointment was made and they came, an engineer, a roadmaster and two attorneys, and we held a "talkfest" of a couple of hours duration. They had all the bills that we had refused to pay, also some that we hadn't heard of before, amounting altogether to nearly two thousand dollars, which they claimed we ought to pay. The largest one, about eleven hundred dollars, was for a crossing where we told them we had not done any work, but they insisted that we must be mistaken because there was the bill to prove it. They argued that they had as much right in the streets as we, and that since the work was made necessary by our digging a trench under their tracks we ought to stand the expense of doing it. We contended, on the other hand, that we had the right to lay our pipes in any street of the city, and the fact that their tracks happened to cross a street could not deprive us of that right; furthermore, that the protection of their tracks was a voluntary act on their part and therefore they could not collect for it from us. So we agreed to disagree.

Last summer we held another conference on the same subject at which they informed us that they had discovered that the largest of the bills, referred to above, was for work done on account of a sewer, so they had to strike that one off their list. They then proposed to accept about one-half the amount of the remaining bills as a full settlement, in order to clear up the old matters, and to make an agreement for the future by which we would pay them the actual cost of the work. This proposition we also refused, and so the matter stands at this writing. We expected to lay two mains last summer in streets crossed by their tracks, and we told them that when we were ready we intended to lay those mains, and if they didn't protect their tracks we would do it ourselves. They said if we attempted it they would ask for an injunction, but we didn't get to it last season so the outcome is yet undecided, although I am told that they have already provided the timbers for that work. We shall probably start on those mains early this spring, so we shall know before long where we are at.

While this matter was before us I wrote to the water departments of a number of cities in our vicinity for information, but found that there was not sufficient unanimity to establish a rule. Several of the cities replied that the question had never been raised. In Detroit the water department does pay the railroads for protecting their tracks, and in Toronto it is provided for by law. Buffalo is in the same position as ourselves, the railroads having rendered bills, payment of which has been refused, and the question has not been definitely settled.

The stand we have taken, as I have outlined it to you, is the decision of our board of three members, but in conclusion I want to give you my individual opinion. While we have the right to lay our pipes anywhere in the streets, we have no right to injure or endanger anybody's property in so doing; therefore, when we dig a trench under a railroad track we are bound to effectually support such track at our expense. The railroad people are more competent to determine what constitutes a proper support for their tracks than we, and if, in the interest of safety for their trains, they prefer to do the work themselves, it seems to me that in common fairness, without regard to the legal aspect of the case, we should pay at least a proper proportion of the expense. What this proportion should be is a question for discussion and agreement, and I am not prepared to say that we should not pay the entire expense, although I believe that in order to secure absolute safety they make the cost greater than necessary. On the other hand it is certainly worth a good deal to us to be relieved of all responsibility in the matter, which should also be taken into consideration. A distinction should also be made between laying mains and repairing leaks, because the latter are accidents beyond our control and may have been caused by the jarring of the passing trains.

DISCUSSION

President Mason: Gentlemen, this interesting paper is before you. It is very important to know just upon whom the responsibility is to be placed. I know something happened just opposite Albany not so very long ago. The question was whether the abutment of a bridge crossing tracks broke the sewer or whether the sewer hooked itself up against the abutment. There was a good deal of discussion over it. This question being a kind of a first cousin to that, it is before you for comment, gentlemen. What is to be said?

Mr. Dow R. Gwinn: The New York Central, Missouri Pacific, and some other railroads now have a form of lease which they require water and gas companies to sign before passing under their tracks. I do not know that they have any right to insist upon that lease, but when I ask for crossing permissions they present the lease and blue print or drawing showing the method in which the crossing is to be made, and the lease requires that the water or gas company shall incase their pipe inside of an iron pipe of a larger diameter, some of the railroads provide for an iron encasement, and others for a tile. The idea is that this casing must extend beyond the tracks a distance of not less than three feet from the rail on both sides, so that if there should be a gas or water leak, the gas or water would be conveyed to one side of the track and not interfere with the operation of the railroad. Then they charge $5.00 for making out the lease, and $5.00 a year so long as the pipe remains there. They also claim the right to order the company to remove the pipe.

MR. J. D. BARNETT: The peculiar twist, Mr. Chairman, that this matter takes when it gets into the legal mind has interested me. In Canada, in Ontario, there has been a good deal of opposition on the part of the railways to permitting municipalities and farmers putting pipes through for the supply of water or for drainage underneath the track. The legislature took up the matter, with the result that that whole business is under the control of the legislative railway committee. If you as a farmer apply to that committee for permission to run drainage under the railway track, and the committee grants the permission, you can perform that operation against the wishes of the railway, you can do the work yourself; but while the work is being done you have to pay the wages of the railway officer who shall be present to see that the track and traffic is exposed to no risk. And really that is all that is legally required and meant by the statement that the water department in Toronto pay for their work. They may permit the railway to do the work, but the legal status of the matter is that the water works can do it themselves, simply paying the railway for the inspector. Now the legal aspect to which I alluded at first is that the railways have taken the ground that because legislation was granted to permit the farmer to go underneath the track, therefore nobody can go underneath the track unless he complies with that legislation. They take the ground that that legislation has robbed the municipalities of all rights whatever to put a pipe down in the street if that street crosses a railway track. You can see some further possible complications there. I am still fighting that out with the Ontario government. The awkwardness of the situation from the railway point of view is that legislation entails no punishment, so that although we are putting the pipes underneath a railway against their protest, they cannot punish us.

MR. W. H. RANDALL: As far as Toronto is concerned, we did have considerable trouble some years ago with the railways, but now all that is necessary for us to do is simply to telephone the proper officer connected with the railway, and they have an inspector there. We do all the work and pay the cost of it, and also the cost of the inspector. We have not had any trouble during the last two years. We have a great deal of pipe under the rails. Whenever a leak takes place we simply notify them that we are going to repair it, and they have a man there during the time.

Mr. S. J. Rosamond: I had one of the leases and contracts referred to by Mr. Gwinn presented to me by the Missouri Pacific Railway system. It has been my practice to notify the proper official of the railway at least a week in advance, where it is possible to do so, before attempting to go under their track; never, however, conceding that they had any right to prevent us from so doing. About the time they formulated a method by which water companies and water districts, or municipally owned plants, should go under their tracks, I had occasion to lay a line that had to go under their tracks. I notified them when I was going under, and the day I started the work they had a crew of men there to stop me, but being forwarned I notified the chief of police what I was going to do, and he gave me ample authority to protect myself and my men. They went to their attorney, who was a very good lawyer, one of the best in the state of Arkansas, and undertook to get out an injunction; and he brought out one phase that has not been touched on here and that I think is a very important one. He held that the city had complete control of the streets for the purpose of the distribution of gas and water and for drainage; that while the railway may require the work in passing under the track to be done in such manner as not to injure the property of the railroad company, yet where it was necessary for the health and the comfort of the community the work must be done. The point I wish to emphasize is that the franchise of a water plant, if it be a company owned plant, has perhaps in many cases been granted before the right to lay track along or across streets was granted to any railway; and that franchise having been in existence before the railroad had acquired any right gave priority of right to the water or gas company. In the case of a sewer the attorney held that all rights were reserved. Since that time we have had no trouble, there has been no objection; and we merely notify the proper official now when we are going under their tracks. We take care of all the expense, and in addition to that we put a watchman on the ground. In most instances the railway company have one man there to represent them, just to see that there is no accident. I believe from my experience that work of this kind can be carried on without friction between the railway company and the water plant, if it is properly taken up in the first place, and that the rights of each party will be respected. I have never had any trouble except in that one case.

Mr. Henry L. Lyon: I think you will find there is a great difference as to whether the plant is owned by a private company or municipally. There are some decisions by the courts which provide that a railway corporation must take care of its own tracks. I have had that up in Buffalo within the last year with the railroads, and I have had the opinion of the attorney for the New York Central, Lake Shore, Pennsylvania, and one or two other roads there. I told them I was going under their tracks with a 48 inch main, and I insisted they must support their own tracks, and they did it without objecting, they came to my office and said I had a perfect right to tell them to do it.

Mr. Alexander Milne: One point with reference to crossing tracks I think is rather a peculiar one, and of importance to both the railroad and the water plant, with reference to the casing of the main by another pipe. If the main is encased in another pipe jointed or otherwise, and a leak occurs the water might be running for some considerable length of time before it is discovered. I think it is a very bad feature to continue the casing over the water main for the entire distance of the track crossing as required in some cases by the railroad; for the reason that in searching for a leak or break in that extended section you might have to uncover a very large portion of the trackage before discovering the leak, and the leak might attain considerable magnitude before being discovered at all. The better practice in larger sized main construction is to lay the main in a tunnel where it is entirely accessible, by putting in concrete or stone walls, and a roof of such strength as to carry the entire load; that being the practice now carried out in Buffalo.

Mr. S. J. Rosamond: We had that lease and contract up with the railways in our locality. Two of the railway lines insisted upon our complying with their regulations, which are as stated by Mr. Gwinn; but I took the matter up with the engineering department of each road on the lines suggested by Mr. Milne, and it has been waived. We put the pipes under in the usual manner, putting them however at the depth they require, which is four feet in our city. I do not think that is an unreasonable requirement as to depth. It certainly gets the pipe low enough, unless it is a very large one, and keeps it from being damaged by vibration.

Mr. Dow R. Gwinn: We have not found the railroad companies unreasonable. I believe it is a good thing to have the pipe encased anyhow. It is not necessary to extend it very far in a series of tracks, but have the pipe come in between the tracks so that if there should be a leak the water would be carried outside and come out between the adjoining tracks. I think it is a good thing to take the jar of a heavy train off the water pipe; there is much less danger of resulting leaks. When pipe is enclosed the jar comes on the casing rather than on the main itself.

Mr. W. S. Cramer: Speaking from the standpoint of a privately owned plant I would say that at one time a railroad objected to our going under their tracks, and put a force of men on the ground to stop us from going through. We simply stopped work and notified the mayor that under the terms of our contract we had to extend a main when ordered by the city, that we could not run the main as ordered by the city council because of opposition by the railroad. We put it up to the city, and they took care of the matter. I think any privately owned plant can fall back on the terms of their contract, and the city would be forced to open a way for them.

Mr. M. L. Worrell: Speaking for a municipal plant, at Rome, Ga., we had some extensions to make in 1908, and the first line of pipe went under the track of the Southern Railway Company that had been laid about fifty years, I believe before Rome was incorporated. When we started under we were stopped by a gang that was a little bit superior to ours—that is, in numbers; but I reinforced my gang during the day, and the next morning we had a larger crowd, and went under the track. We had not yet back filled, and during the night they came along and back filled for us, which was appreciated. They denied absolutely our right to go through although it was a public street of the city. However, we got through. A little bit later we had to cross under about ten tracks and a switch. They tried to stop us there. Foreseeing the probability of some trouble arising, at a special meeting of the city council I and my foreman were clothed with police powers. We arrested some men and carried them off in an automobile, and went under the tracks anyway. We supported that track so that it was perfectly safe. Since then, they see they are up against the law or the powers that be, they of course have yielded, and sent a man or two to help us out. When we crossed their private right of way, which we had occasion to do later on, we had to sign a lease.

Mr. Willis B. Durlin: I was in hopes before the convention that we would have gotten through with the work on two mains that I spoke of, so that I would know whether the threat of their taking out an injunction would be carried out. We have not gotten to it, as our other work is pressing. I think myself that they are bluffing; but of course you cannot tell whether a man is bluffing until you "call" him.

Mr. A. A. Reimer: We handle this problem as it comes up in the individual cases, treating each one on its own merits. If we feel that the crossing of a track or making of repairs are needed and will be a benefit to the city, and in many cases would put the railroad to no serious expense, or cause them trouble, or force them to put inspectors on the work, or anything like that, we go ahead with it. We consider each case separately, and decide whether we will pay the bill; so that now, the railroads finding that that is our attitude, simply ask us before sending a bill if we will honor it if sent. That does away with any dispute. On receipt of their letter asking if we will honor the bill I present the matter to the board and state the conditions to them just as they have occurred, and the board then decides whether the bill will be honored, and I notify the railroad of their action. If the bill is to be honored we pay the bill promptly; if not to be honored, we hear nothing further from the railroad. In that way there has always been perfectly good fellowship between the municipality and the corporation; there has been no friction certainly in the last five years. Six years ago there was a little friction, but none since that time. We get along very nicely, and try to treat the companies well.

Mr. J. W. Ledoux: I am engineer of a company that runs pipe along the railroads, especially the New York Central and the Pennsylvania. We have had occasion to cross the railroad in a number of cases, and the New York Central rule is that the pipe shall be encased, especially under the main tracks; where it is under a siding or unimportant railroad they do not require it; but in all cases on the main line they require it. With the Pennsylvania it is the same. I think that rule is in practice on both the New York Central and the Pennsylvania railroads on the main line.

Mr. Edmund T. Sykes: I have had an experience of some twenty-five or thirty years with crossing railroad tracks. It is my opinion that the water plant is not liable for any bill whatever. Of course the question is a large one and the legal aspects may vary in different states. I am informed by the chairman of our water committee that so far as the legal questions are involved there have been more decisions upon water in Minnesota then perhaps any other state.

Twenty-five or thirty years ago when we had occasion to cross the railroad track we simply notified them that we were going to cross it, and they would say that we could not cross unless we took care of the track. We would simply notify them that we were going ahead, and they always had a man to take care of the track. I presume that we cross tracks once a week in Minneapolis. We simply notify them by letter that we are going to do it. We do the work so thoroughly that it does not require any support from them as a rule. I think in most cases they do not do anything at all. I am not an attorney, but having done such work in different cities, I am inclined to think that in an ordinary city street which is maintained by the city that when the matter comes to a final decision by the courts the railroads would have to take reasonable care of their tracks.

Mr. Henry L. Lyon: (by letter) In Buffalo, we have had some talk with the different railroads as to whose business it is to support their tracks during the laying of any new water mains, or repairing old ones. In each case where the main has been through a public street which the railroads crossed the railroads have supported their own tracks. I find in "Abbott on Municipal Corporations," Vol. 3, Page 2036, Section 856, the following which may be of interest:

> The duty usually rests upon the railroad company occupying a highway, in case a change of grade is made, to reconstruct its track at its own expense so as to conform to the changed grade.
>
> North Chicago City R. Co. v. Town of Lake View, 105 Ill. 184; Indianapolis & C. R. Co., v. State, 37 Ind. 489; City of New Orleans v. New Orleans Traction Co., 48 La. Ann. 567, 19 So. 565; Water Com'rs of Jersey City v. City of Hudson, 13 N. J. Eq. (2 Beasl.) 420; City of Albany v. Watervliet, 108 N. Y. 14; Ashland St. R. Co. v. City of Ashland, 78 Wis. 271.
>
> The performance of this duty in some instances has been held to include not only the reconstruction of the track at the expense of the railroad company but also the cost of raising that portion of the street occupied by tracks to the new grade as lawfully established.
>
> City of Little Rock v. Citizen's St. R. Co., 56 Ark. 19 S. W. 17; West Chicago St. R. Co. v. City of Chicago, 178 Ill. 339, 53 N. E. 112; Borough v. McKeesport Pass. R. Co., 158 Pa. 447, 27 Atl. 1006.
>
> The principle further obtains that public authorities may disturb the tracks of a company using the highways for the purpose of making proper improvements, the construction of sewers, laying water mains or the like and that any charges or expense caused by these acts to the railroad company in the temporary displacement and replacement must be paid exclusively by the company.
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> National Water-works Co. v. City of Kansas, 28 Fed. 921; Kirby v. Citizens R. Co., 48 Md. 168; Middlesex R. Co. v. Wakefield, 103 Mass. 262; City of Detroit v. Ft. Wayne & E. R. Co., 90 Mich. 646; State v. Corrigan Consol. St. R. Co., 85 Mo. 263; West Philadelphia R. Co. v. City of Philadelphia, 10 Phila. (Pa.) 70.
>
> Des Moines City R. Co. v. City of Des Moines, 90 Iowa, 770. 58 N. W. 96, 26 L. R. A. 767;
>
> McMahon v. 2nd Ave. R. Co., 75 N. Y. 231.
>
> Clopp v. City of Spokane, 53 Fed. 515.
>
> Warren v. City of Grand Haven, 30 Mich. 24.

ACTION OF ST. LOUIS WATER ON METALS AND ALLOYS

W. F. MONFORT

The subject matter of this paper might with equal propriety be discussed under a more general title. I have chosen to refer to all of the reactions as of local occurrence, not because they are characteristic of St. Louis water only—in the main they are of general occurrence—but because some of the observations made are of peculiarities incident to the distribution of a partially softened water.

That the character of the water may be understood, a brief résumé of the process of treatment is given.

Water from the Mississippi River is taken at a point about five and one-half miles below the mouth of the Missouri River. Treatment with sulphate of iron and lime prepares for rapid subsidence of suspended matter during the passage through six sedimentation basins whose combined capacity is about one hundred and fifty million gallons—approximately two days average consumption. From these basins the water flows to two high service stations, whence it passes to the distribution system.

The table following shows the important components, after evaporation of a representative sample during the low water period, when the alkalinity was 120 parts per million.

Calcium carbonate	60.5
Calcium sulphate	13.9
Magnesium carbonate	55.0
Sodium chloride	34.2
Sodium sulphate	85.0
	273.0

However, in solution these various calcium, magnesium, sodium and other compounds are probably dissociated. We may say that it is an one-thousandth normal solution of calcium (factor 1.4); with respect to magnesium it is $\frac{N}{1000}$ x 0.6; with respect to sulphate ions it is $\frac{N}{1000}$ x 1.6; with respect to chlorine, $\frac{N}{1000}$ x 0.35; with respect to carbonate ions, $\frac{N}{1000}$ x 0.84. Looked at in this way it seems very far removed from water; and if the aggregate concentration of basic or acid ions be considered, we have approximately a factor of 3.1. In other words this solution—water by courtesy—has a concentration with respect to total acid ions corresponding to an $\frac{N}{322}$ acid. We may say it is of one-sixth the strength of an $\frac{N}{50}$ acid such as many of you use in determining the alkalinity. Its conductivity is rather greater than that of such an $\frac{N}{322}$ acid. This complex solution may be regarded as furnishing ample means of transport for electrical charges as metals immersed in it pass into solution.

The dissolved matter acts in two ways: First, As a supersaturated solution of calcium carbonate, it has a specific action characteristic of softened waters. It furnishes a protective coating to surfaces which it touches during the completion of the softening reactions.

It has been stated above that the city water is treated with lime. Because it is a softened water much of the calcium and magnesium present are in the form ordinarily called neutral carbonates. The softening process is completed slowly at high temperatures and at winter temperatures is incomplete even when the water passes to the distribution system. There is therefore more or less deposit in mains, laterals, and service pipes, which forms a closely adherent coating over metal surfaces. During the earlier period of softening at St. Louis the attempt was made to carry the softening effect to the limit produced by the use of a large excess of lime. The extreme thickness of deposit occurred in this period.

When chemical treatment was first installed very high caustic alkalinity was of frequent occurrence. So far as the incomplete records of the department for this period are available this seems to have been thought desirable, or at least unavoidable. The prime purpose of treatment was clarification. Thus in 1905, during five months the average caustic alkalinity of water distributed was 11.9 parts per million. That the attempt to carry the softening to the limit, resulting in persistent caustic alkalinity in varying degrees, not only through the settling basins but in the distribution system, might produce heavy incrustation throughout the city was not apparently considered. During the last four years the effort has been make to avoid caustic alkalinity, and to maintain from day to day as nearly uniform a character of water as the conditions allowed.

But even with the moderate use of lime which has been the mode during the past four years the protective coating is not wanting. One is reminded of the expression "laudable pus" which was in vogue during the last illness of one of our assassinated presidents. In time this coating may become so abundant as to reduce small openings, and by its roughness materially increase friction in the distribution system. But for our present consideration the deposit acts in a way beneficial, so far as the life of metals in contact with it is affected.

The second general manner of action upon metals is electrolytic. It is occasioned by the behavior of pure water, accelerated by the dissolved salts of sodium, magnesium and calcium, and further accentuated by the presence of impurities or variations in composition of portions of the metals which are in contact with the water, giving rise to local galvanic couples.

The cases to be cited are the action on iron, on zinc, on alloys containing zinc, and on aluminum. These are the metals commonly or occasionally used in the distribution system; aluminum in air relief valves, for example; brasses and bronzes in meter trains; zinc in alloys and in galvanized iron; iron in mains and pipes. The only constituents of the local water not common to all supplies, which have a specific action, are those carbonates of magnesium and calcium which give a red coloration with phenolphthalein; that is, the neutral carbonates. The other constituents are common to all natural and treated waters in greater or less degree.

ACTION ON IRON

It has been shown by Walker and by Cushman that pure iron in air-free distilled water is slightly soluble, that in the presence of dissolved oxygen the metal is oxidized, and that the presence of various carbides in steel and of minute traces of impurities in soft iron serves to create differences of potential, resulting in a more or less rapid oxidation of the metal, with pitting, tuberculation, and ultimate disintegration. Now, in water such as ours, containing salts of various kinds, whose solutions are conductors of electricity—that is, electrolytes—these reactions are very much accelerated. All steels and all iron used in water works practice carry the requisite impurities to cause the formation of local couples. And yet—notwithstanding this susceptibility of iron—there are many large installations of black iron pipe in constant use throughout the city. It may be said that in the water department iron pipe is regularly used. It is questionable if the additional cost of galvanized iron pipe and fittings secures a commensurate increase in durability over that of the cheaper, plain iron installation. The fact remains that the "red water plague" does not occur with us.

The explanation lies in the action of hydroxyl ions. Pure water ionizes to a slight extent, giving hydrogen and hydroxyl ions. If a substance which dissociates in solution giving hydroxyl ions be added to pure water the formation of hydrogen ions is inhibited. It has been shown by Walker that the oxidation of iron occurs at the point of liberation of hydrogen ions. When calcium carbonate dissolves in water hydroxyl ions are liberated; their presence may be shown by the use of phenolphthalein, which is reddened by them. Another substance which gives hydroxyl ions in solution is calcium hydroxide, or slaked lime. The plasterer's custom of leaving steel tools in lime water to prevent their rusting is well established. Now calcium carbonate dissolves much less readily, and is less effective than calcium hydroxide, but hydroxyl ions are formed, and retard, though they do not altogether inhibit, the liberation of hydrogen ions with the resultant oxidation of iron. I do not mean that no oxidation occurs; but that the amount is slight as compared with that occurring where a water supply contains little or no neutral carbonates. The drip from taps over porcelain fixtures does not produce an iron stain. To this extent the inhibitory effect of the hydroxyl ions is a protection.

As to the action on cast iron mains, it may be said that the facts thus far brought to light indicate a similar protected condition. A 30-inch main was replaced last year by a 36-inch line, after 32 years' service. The old line had been in use therefore about 26 years before the present method of treatment was installed, and part of the effect to be described was doubtless due to causes operative throughout the earlier period, when muddy, untreated water was distributed. This was one of the oldest trunk lines in the system.

In the upper part of the sections was found a coating of calcium carbonate overlying a layer of hydrated ferric oxide, on the lower part additional matter was noted. Qualitative examination of the still moist deposit showed beneath the film of calcium carbonate and tubercles of iron oxide, and covered by them, a greenish black layer which contained abundant sulphides. a black semi-crystalline substance resembling hydrated ferrous oxide, with some carbonate. Shaken up with water this dark colored matter developed the characteristic odor, taste, and color usually connoted by the expression "dead end." Occasionally after extraordinary demands upon the distribution system, as in fighting large fires, the overlying coating of calcium carbonate is disturbed and water from taps in the vicinity is described as resembling the best known local sulphur water.

The sulphur of the sulphides present may have been derived from the cast iron of the pipes; but a more probable source is the sulphates normally present in the untreated water, reduced by the action of exposed iron, with the aid of minute organisms, perhaps. It is a misnomer to speak of dead ends in this connection, for such a deposit occurs in trunk lines in which large volumes of water are continually passing.

In mains recently laid such sulphur compounds have not been noted. Observations thus far warrant the belief that the inhibitive action of hydroxyl above mentioned as affording a measure of protection to iron is effective here, and that this deep lying deposit in the case of the older mains antedates the distribution of softened water.

NOTE—Those desiring to read the original papers on the electrolytic theory of the corrosion of iron are referred to Bulletin No. 30, Office of Public Roads, issued by the Department of Agriculture, and to the paper by Walker in the Journal of the American Chemical Society for September, 1907 (Vol. xxix, 1251–1264), where the data are much better discussed than in any other statement thus far appearing. Reference is made in these papers to important previous contributions.

ACTION ON ZINC

The use of galvanized iron in residential installations is general. I had occasion a year ago to refer in a paper before this association to the action of our water upon this material.

A new meter with a galvanized iron cup, subjected to unusual service during twenty-four days, registered 128,266 cubic feet, or 961,995 gallons. Upon removing the cup at the end of this period it was found to contain a soft, adherent, yellowish-white coating, which was analyzed, and found to contain about 75 per cent of hydrated zinc oxide, with traces of calcium and magnesium compounds. The cleaned surface showed a hard, brittle black layer about $\frac{1}{100}$th of an inch thick, rich in sulphides and in carbon, overlying the cast iron body of the cup, with only traces here and there of the original zinc coating, which had been almost entirely removed or converted in place into zinc oxide and basic carbonates. No pitting or tuberculation of the iron had taken place.

It appeared in pipes examined that the irregular coating of zinc, originally present, was converted into an extremely rough, voluminous coating of secondary product, materially diminishing the bore of the pipe, and rendering very little real service in protecting the iron surface.

Pure zinc dissolves appreciably in pure water in a brief period of time. Its tendency to dissolve—solution tension—is very great, exceeding that of iron, and very much greater than that of copper or of tin. A piece of fairly pure zinc, containing 0.014 per cent iron, and 0.050 per cent lead, immersed in a 1 per cent jelly of agar made up with distilled water and 2 per cent standard phenolphthalein solution shows the presence of hydroxyl ions in a few minutes. By the addition of a trace of ferricyanide of potash it can be shown that the zinc passes into the jelly at points which are not giving off hydroxyl. The same reactions take place more readily when water containing salts is substituted for distilled in preparation of the jelly; the indicators show the passage of the zinc and hydroxyl into the jelly almost instantly.

I have referred to the use of agar jelly in showing the immediate formation of hydroxyl ions when there is a reaction such as zinc or iron show resulting in the passage of their ions into solution, because we shall need this reaction in discussing the behavior of alloys.

ACTION ON ALLOYS

My attention has been called to the action upon certain alloys used in meter trains. Employes of the Tap and Meter Department have shown me numerous examples of destructive action, with the remark: "In nine cases out of ten when a meter of this make fails to register, it is found that the gears have completely collapsed." The failure results apparently from a degeneration of the alloy at one or both ends of the posts or studs which bind the frame together.

Analysis showed that at least three distinct alloys were used in different working parts of the gears which gave the trouble. The posts were high in zinc; the frames contained less than one-half, and the pins and screws about one-fifth as much zinc as was in the yellow posts. In one extreme case of failure these high zinc posts had been converted into a porous mass, adherent, but so weakened that the whole crumbled under pressure of the fingers. There was one gear in particular from which one post was powdered in a mortar. Under a microscope the particles had the appearance of spongy copper interspersed with greenish and almost white particles. Analysis showed the absence of zinc and the presence of 92.9 per cent copper and 1.09 per cent tin. The appearance of the metal remaining in the posts suggested that local action had resulted in the wasting of zinc. In view of the dissimilarity of the alloys in contact at the points of fracture, it seemed probable that there would be sufficient difference in potential to be detected by the delicate reaction with phenolphthalein, when these alloys were wholly or partially immersed in agar jelly.

Jelly prepared with distilled water, or with tap water, had too low conductivity to show the result. But with a jelly containing 0.1, 0.05, 0.025, or even 0.0125 per cent of salt (sodium chloride) the separation of hydroxyl ions about the higher copper alloys was apparent in from one minute to twenty-four hours, when the train entire or partially assembled was immersed in it. Calcium sulphate, sodium sulphate and other electrolytes in sufficient concentration work equally well; for this is not a reaction wherein specific acid ions are requisite; given only an electrolyte and the reaction proceeds similarly.

Once the removal of zinc is begun, the process must go on to completion. For a high zinc alloy in contact with copper gives up its zinc rapidly and with increasing speed. It is only necessary, therefore, that the saline content of the water be great enough to invite the reaction. Thereafter a minimum concentration suffices for its continuance until the yellow alloy is degraded.

Usually the parts are weakened at the points of contact long before the middle of the posts are seriously affected, with the resulting break commonly coming at one or both of the screws which hold the frame together.

Deterioration of this character occurs equally on new and old distribution lines. The latest case noted was reported April 23, 1910, from a point in the northern part of the city, on a relatively new main. In this instance some screws, apparently of commercial brass, were engaged by parts made of lead alloy. The soft portions remaining from the screws were punched out and new screws turned into the old threads.

Some facts recently developed suggest that the destructive action referred to occurs in meters set during low stage of the river, when dissolved salts are near the maximum concentration, while those meters set during periods of relatively high stage, and low saline content receive a thin film of calcium carbonate which serves as a protection to the weak portions of the trains, then they are later exposed to the action of more highly corrosive water. For example a meter set December 31, 1907, was very badly corroded in two years; while others of the same make set at more favorable time have given good service for a much longer period.

Looking at the facts in the light of the demonstration which the foregoing experimentation has outlined, further explanation is not demanded. The zinc of the yellow alloy has pushed into solution to escape from a condition of unequal tension which the manufacturers have unconsciously brought about. In the progress toward equilibrium a worse state has arisen, culminating in a breakdown of the mechanism.

The attempt made a year ago by the manufacturers of this particular meter to obviate the difficulty by tinning the wheels is of no avail. A new train immersed in a jelly containing 0.0125 per cent of salt gives hydroxyl over night. Tin does not protect iron even; much less does it protect zinc.

The solution of the difficulty lies in eliminating high zinc alloys and using one alloy throughout the train, frame, posts, and case, making it after the order of the "one-horse shay." With alloys of equal potential there will be some local action; both copper and zinc actually waste from an alloy at the same time in salt solutions, as my experiments show; but the resulting weakness will be better distributed, making the life of the meter longer.

This trouble is not confined to one locality. It has occurred at points other than St. Louis. With waters containing high percentages of saline constituents such as abound in the Western States it is impossible that this electrolytic action should not be wide spread. It must occur wherever alloys of high and low zinc are used in meters in such waters.

ACTION ON ALUMINIUM

My attention was called to the deterioration of aluminium in some air relief valves used in the department. Some of the parts were of aluminium in contact with brass. After a time the white metal was found coated over with hydroxide, and deeply corroded. The result was natural, but the manufacturers seem not to have taken into account the behavior of different metals in contact. In the light of some experimental facts developed later, there could have been no avoidance of the trouble with untreated or with softened water in contact with commercial aluminium alone.

With distilled water containing so little as thirteen parts per million calcium carbonate, or thirty-five parts per million sodium chloride, or with a solution of these two components in these amounts, hydrogen is evolved in measurable quantities by commercial aluminium, while the surface of the metal is covered over with a film of hydroxide, save where strong centers of local action occur. Eventually the action in still water becomes very slow by reason of this protective coating, resembling an enamel in appearance; but in running water pitting is very severe and prolonged.

SUMMARY

The water supply of St. Louis by reason of its content of neutral carbonates exerts a two-fold effect during distribution:

1. *Physical:* A protective coating forms on surfaces exposed.
2. *Chemical:* Specific action of hydroxyl ions largely inhibits the corrosion of iron.

The dissolved saline matter increases the conductivity of the solution, and thereby accelerates electrolytic action.

The waste of zinc under these conditions is quite rapid. Zinc, even in alloys, possesses a high solution tension, giving rise to marked differences of potential between alloys of different zinc content.

This can be demonstrated by the use of agar jelly containing phenolphthalein with alloys of different zinc percentages.

For this reason zinc alloys of widely different composition suffer marked deterioration when combined in systems exposed to such strongly saline water, by the wasting of the constituent of highest solution tension.

Such waste is not inhibited by partial tinning of surfaces.

Commercial aluminium reacts too readily with even moderately saline waters to warrant its exposure in working parts.

It is important that, so far as possible, only homogeneous materials be placed in contact in such a water.

DISCUSSION

Mr. W. F. Monfort: In presenting this paper the purpose was to call attention to the action of a perfectly soft water on metals and alloys that are used in distribution. I will make no apology for the restatement of old facts. It is necessary occasionally to rediscover the Ten Commandments. The old facts in this paper are not the Ten Commandments, but they are commandments with regard to the use of alloys in water containing certain chemical constituents. The penalty is as pronounced as it is in the case of the Commandments.

Those of you who are interested in the theoretical side of this question are familiar with the historical development of the electrolytic theory of the corrosion of iron, and such will do well, if they have not already secured it, to get a copy of Bulletin No. 30 published by the Department of Agriculture. It is by Cushman, who has contributed very important results to the investigation. There is another very important paper by Professor Walker of the Massachusetts Institute of Technology, that has appeared in a number of periodicals, and perhaps in its most complete form in the Journal of the American Chemical Society for July, 1908. The earlier contributions that are of importance are mentioned in the Bulletin No. 30 that has been referred to, and which may be used as a bibliography. It may be stated that Dr. Walker's paper presented in full is not listed there, although it is referred to.

PRESIDENT MASON: This subject is one of growing interest. I cannot help but feel that possibly one point that presents itself to the mind of the average water works man is, that it would be wise if he could only lay his finger upon some prophetic statement as to what a water was going to do with reference to the metal that he proposed to use; that kind of information would be better and more advantageous to him than an analysis of the water after the water had caused the trouble. I think that I have already referred to that in a previous talk a year or so ago. I also reported here a specific case where a man had spent much money in attempting to place a spring water upon the market to the very best advantage, and then found it was loaded up to the muzzle with zinc; when, had he spent much less money to obtain this information in advance, he would have gotten along better and more cheaply. I think therefore that water men are likely to ask their analysts after this for a prophetic report that will furnish what the probable effects will be after the water passes along in contact with some specific metal that they are going to use. As to going into the method of doing this, that would be rather out of the line of the work of this convention. I think I have already reported it anyhow. It seems to me that the question of the action of water upon metals is a very vital one, and that this paper is a very valuable contribution to the subject. What will you do with it, gentlemen? Is there any discussion?

MR. J. W. LEDOUX: Mr. President, had we not better appoint a committee to report on the subject? I think it would warrant further investigation. There are some places where the difficulty of preventing water from corroding the service pipes is extremely important, and in the event that information can be obtained by inquiry of managers of water works, I think further investigation of that kind should be had, and that it will prove valuable.

President Mason: If that is made as a motion I should be glad to entertain it. I cannot help but feel, however, gentlemen, that we are loaded with committees already, and possibly what you are after can be at least as well secured in the shape of papers, especially if they are prepared by men who have devoted their time and attention to that particular topic; whereas a committee that would be appointed might not be men of that kind. I really think that the end would be obtained in the shape of papers—with your permission.

WATER RATES AND EXTENSIONS

J. W. LEDOUX

In line with some of the previous papers and discussions the writer desires to consider two phases of the operation of a water works. The first is what method or system may be used to establish water rates that shall at the same time be fairest to the owners and to all grades of consumers. Under all circumstances there must be a sufficient gross revenue to pay for the cost of operation and the interest on the investment. If the rates could readily be changed every year or two, and the works were operated upon only a self sustaining basis, there would be no necessity to make any allowance for depreciation; for when it was found necessary to renew a worn-out or broken part, the rates could be raised a sufficient amount to pay the interest on the cost of the renewal. The adoption of this principle would also avoid the great complication involved in trying to estimate, or rather guess at depreciation, in advance. There is nothing more uncertain than life. Take even a standpipe—one of the simplest structures in water works' use—under some conditions they will last for, say, five years, and under others, fifty or more years. No one can tell, or even approximate the life of a pumping engine, reservoir, pipe, valve, or hydrant, although there are volumes written on the subject. It may be not difficult to charge off a certain amount based on the average of a large number of cases; and if this charge were put in a general fund covering a like large number of cases, as are insurance premiums, the solution would be logical and closely approximate; but the practical difficulties in the way of effecting such an arrangement would be insuperable.

In a municipally-owned water works there are no serious obstacles which interfere with the change or establishment of water rates. If they are too high or too low, they can be changed, or the tax rate changed. With a water company, every act which tends to increase the burden to the water consumers, is condemned alike by both consumers and city officials, even if such an act is essential to the very existence of the water company. Generally such an object can only be effected by legal proceeding, and then the difficulties become so great that both sides actually resort to some make-shift compromise long before the case has reached any satisfactory adjudication.

The writer is not familiar with all the various legal decisions, but believes that in one of the most important cases in England, the law was laid down that a water company was entitled to a sufficient return to pay the interest on the investment, the cost of operation, for the loss due to depreciation, and also for an annual sinking-fund to retire the bonds, or mortgage, in a reasonable time and for a fair return to the owners or promotors in the shape of dividends.

At first sight there might be objections to the sinking-fund, but a buyer of bonds cannot consider his investment entirely safe and quite desirable unless there is due provision made for redemption within some definite time, and as this period usually extends from twenty to forty years, it may be assumed that at the end of that time, or when the bonds are retired, the rates can be lowered an amount equivalent to that required to maintain the sinking-fund. Others might object to the provision for dividends to the original owners or promotors, but it was due to their efforts, enterprise and ability that the project was organized, launched, financed, and successfully brought through the early and unprofitable stages of its existence. Hence they should be entitled to reasonable compensation, either in the shape of dividends, salaries, or an equivalent combination of both. In the case of the municipally owned water works, there is no necessity for this last provision, and therein lies an advantage in favor of municipally owned plants; but generally speaking this is more apparent than real, for many reasons, to enumerate which would lead to a discussion of the relative merits of private and municipal ownership, for which, like free-trade and protection, either side can be defended apparently by the most conclusive arguments.

As a general proposition it may be stated, that to be equitable, the rates to any consumer should depend upon the following factors:

(1). The amount of water consumed in a given time.

(2). The maximum rate at which he is able to draw this water.

(3). His elevation relative to the source of supply.

(4). His distance from the source of supply.

(5). The number of consumers on a given line of pipe.

(6). The amount he is willing to guarantee the water works periodically.

(7). The length of time for which he is willing to make this guarantee.

Manifestly, some of these factors, as (3), (4), and (5) cannot be provided for in practice without undue complication; so in order to secure the requisite uniformity, we must be satisfied with rates that will be fair to some, bear heavily on others, and give undue advantage to others.

Factor (1) can be provided for by the use of meters.

Factor (2) might be provided for by limiting the size of service connection, or by a rate of flow chart mechanism, which latter few water works men would adopt on account of the expense.

Factors (6) and (7) are practical and easy of application. Therefore, it seems that under present prevailing conditions and practice, we cannot do better than adopt a simple rule whereby a consumer's rate per 1000 gallons varies inversely as the amount he is willing to guarantee the water works periodically. For this purpose there can be used one of two general formulae, either of which is simple, and requires no mathematical training to apply.

The first is the simplest equation of a hyperbola: $x = \frac{a}{y} + b$.

The second, an equation of a straight line: $x = b - \frac{a}{y}$, wherein "a" and "b" are constants, "y" is the minimum number of dollars the consumer is willing to guarantee to pay the water works periodically, and "x" is the rate per 1000 gallons. To illustrate this method let us assume that the water works management is willing to grant to any consumer who will guarantee as much as $550 per year, the lowest rate for water, and establishes a minimum rate of ten cents per one thousand gallons.

To those who are willing to guarantee only $50 per year, 20 cents per one thousand gallons, and to those who are willing to guarantee only $10 per year, 40 cents per one thousand gallons.

Using the second equation, we then have for minimum annual rates between $50 and $550 per year:

$$X = 21 - \frac{y}{50}$$

and for minimum annual rates between $10 and $50 per year:

$$X = 45 - \frac{y}{2}$$

tabulating these equations we have the following:

MINIMUM GUARANTEE PER YEAR	RATE PER ONE THOUSAND GALLONS
$550	$0.10
400	.13
300	.15
200	.17
100	.19
50	.20
40	.25
30	.30
20	.35
16	.37
10	.40

Of course, many modifications of these constants could be adopted to best meet particular conditions; but the principles are so simple, that no objection upon this score can be considered reasonable.

As to flat rates, they cannot be justified by any valid argument. It would be about as reasonable for a coal dealer to permit a customer to help himself to all the coal he desired for a fixed price.

In order to determine the minimum price per 1000 gallons to charge for water, the following illustration shows the method adopted by the writer.

Let us assume the water works has a maximum capacity of five million gallons per day, or a salable capacity of three millions per day, and costs one million dollars. The annual charges may be taken for example, as follows:

(1)	Fuel	$10,000.00
(2)	Coagulent used in water treatment	2,000.00
(3)	Oil waste and pumping station supplies	500.00
(4)	Repairs	2,000.00
(5)	Superintendent, regular labor, team and office force	10,500.00
(6)	Taxes and Insurance	6,000.00
(7)	Depreciation	$15,000.00
(8)	Engineering and legal expenses	2,500.00
(9)	Interest	50,000.00
(10)	Dividends	30,000.00
		$128,500.00

If we assume the revenue from fire hydrants to be $25,000 per year. then there must be obtained from the sale of water,

$$\$128{,}500 - \$25{,}000 = \$103{,}500.$$

which makes it necessary to obtain approximately 9.46 cents per 1000 gallons, below which price it may be considered risky to sell to any consumer.

Water works managers sometimes err, and think because the plant has a certain capacity they should be able to sell all this water, provided they could obtain a sufficient number of patrons. But this is not the case, for many reasons, but particularly on account of what is termed in power plant parlance "Load Factor." At certain times of the year the draught is much heavier than at others; there are also weekly and daily peaks of demand. Then, there are necessary wastes of water that cannot be made to yield revenues—leaky pumps, pipes, and innumerable leaks in house fixtures that no meter can possible register.

The next question concerns extensions which are the bane of private water companies. What percentage of revenue warrants the laying of an extension? Let us assume the extension to cost $1,000, and the entire amount of revenue obtainable be first in the shape of fire service rental; taking the same illustration, we see that the only items of annual charge, numbers (4), (6), (7), (9) and (10) will certainly be affected; but in the illustration these cover 10.3 per cent of the cost, and hence such an extension would be allowable when the revenue is about 10 per cent of the cost.

Suppose on the other hand, the revenue is all derived from the sale of water, and that the cost of the extension is \$1000, as before; evidently, if the extension were a homogenous portion of the original system, 12.85 per cent of the cost would be a reasonable minimum to require; but if only a pipe line, the case is different. Every extension taxes the original plant, and will eventually make it necessary to enlarge the works to provide for such extensions. Let us illustrate by assuming that all the revenue were obtainable by the sale of water, and assume the piping system to cost 60 per cent of the entire cost of the plant. There would have to be obtained for every \$1000 worth of pipe to meet the requirements $\frac{128,500}{600}$ which equals approximately \$214. Therefore, as this is only the average requirements, and the ratio of cost of pipe line to that of the entire works is likely to be maintained, it is not safe to lay an extension for domestic revenue, unless from 15 per cent to 25 per cent of the cost of the extension is guaranteed yearly.

The above is given for the purpose of affording water works managers food for thought, and not to set down any rules that can be followed. For each case is different and must be considered by itself.

HOW TO PROVIDE FOR THE COST OF WATER MAIN EXTENSIONS

WILLIS J. SPAULDING

The question as to how to provide for extensions of water mains from time to time has been forcibly brought to my attention. Springfield is the capital of the state of Illinois. It has a population of sixty thousand to seventy thousand and is a rapidly growing city.

For several years past, the water department has expended about $30,000 annually, or one-fourth its gross annual income, for new mains. Our city is bonded to the limit so that we must pay as we go.

From the writer's limited experience and observation, he is led to believe that all ordinary distribution mains should be paid for by the frontage owners and not from the water fund at all. He wishes to point out his reasons for this belief, and would be very much pleased to hear any criticisms or objections that may suggest themselves to his hearers.

First. We have many more applications for extensions than we are able to make. Each alderman is naturally ambitious to get things for his ward. He gets his ordinance passed requiring the pipe to be laid, then he comes to the water department and explains how this particular extension is absolutely necessary and must be made whether anything else is done or not. Petitions are presented from different parts of the city, and various pleas are made by the individual citizens. Possibly wells are polluted and unsafe, or they may be dry. It may be desired to build modern houses in a new addition, or fire protection is wanted, or a new factory is being located.

After listening to all this, we decide where in our estimation, the need is the most urgent, and let the others get along the best they can.

Being unable to secure a main in front of the property, in many instances, home owners have run pipe at their own expense, costing from \$50 to \$150 for a single residence, rather than wait for the department to lay a main. We have whole blocks and more supplied in this way, and when the water department is finally ready to lay the regular water pipe along this frontage, it finds most consumers are unwilling to incur the further expense of tapping the main in the regular way, having already piped the water to their property in this makeshift fashion at extravagant cost. The result is that many thousand feet of this temporary kind of pipe is in use for an indefinite time. It becomes leaky and is not finally abandoned until it gets so bad that enough water does not get through to supply the consumer, involving much water waste and trouble to all concerned.

When it is realized what a direct effect a water main has on frontage values, it is readily understood why there is so much rivalry to secure it.

A modern house is impossible without water under pressure. The prospective builder asks first, "Is there a sewer, and is water available?" A lot where these things are lacking is not an immediate modern home site, but must be held in waiting until these advantages are there. The home builder is not only willing to pay extra for the actual cost of these advantages in the price of the lot, but he is willing to pay a liberal premium because they are there *right now,* and he avoids the uncertainty and annoying delays involved in finally securing them. The advantages of a street—advantages of every kind, whether of beauty or economic utility—are reflected in the value of the frontage.

It often happens that the department lays extensions in a new addition where there are only scattering homes, about one fourth or one fifth of the lots being built upon. The extension was run primarily to relieve the necessity of those few homes, but incidentally all the vacant lots are made much more desirable as building sites without any expense to the lot owners.

As compared with streets in the same addition where there is no water, the lots on this street are easily worth \$25 extra, other things being equal. So that, while the vacant lot owner contributes nothing to this improvement, the benefit to him is just as real as if he had actually used the water. It is true, the home owner has enjoyed the same increase in the value of his lot, but in his case, the cost of the main is being covered in the water rate, while the vacant lot owner goes "scott-free."

Twenty five per cent of our present water rate is practically an extra charge for laying new mains. The cost of laying the pipe immediately adds at least $25 per lot, sometimes $100 per lot, and is usually collected from those who finally buy the lots for homes, and goes to the pocket of the town lot speculator. The final home maker or actual resident, after paying $25 extra for the lot on account of the water pipe being in, pays again fo the same water pipe by contributing annually 25 per cent in his water rate to pay for new mains.

But the injustice does not stop here. Assuming the main to cost $14 for a forty foot lot (which is about the present cost), and assuming that a consumer uses $14 worth of water per year, the 25 per cent of each $14 or $3.50 set aside to pay for new mains would in four years, have paid enough to cover the cost of the main in front of his premises. But he continues to pay the 25 per cent extra for new mains indefinitely, and in forty years would have paid for the cost of new mains in front of nine other lots besides his own. The consumer would be much better off to pay for his new main outright when it is laid and then pay 25 per cent less for water.

The cost of sewers and of pavements is acknowledged as a legitimate charge against the frontage, and in Illinois cities is paid for accordingly. The value of a water main in front of a lot is much more certain and tangible than either sewers or pavement, because there is scarcely any business or purpose for which the lot could be used that water would not be necessary or desirable. It is like bringing an ever flowing spring—and flowing under pressure—within reach of the lot.

When a city has reached fifty thousand or more in population, wells are frequently unsafe and undesirable. Even where a well is used, fire protection is always wanted, because no protection means high insurance rates, and that value is reflected in all the frontage.

In our city the building of many first class homes is being delayed right now for lack of city water. As soon as it is known to be the settled policy of the city to charge water mains to the frontage, many new additions would be piped before they were offered for sale, the owners knowing that the money would come back to them in the price of the lot with a good profit on the investment. The per cent of profit on money so invested in water mains might easily exceed that usually made on the investment in lots. This would bring new consumers to the water department rapidly, because new mains would be laid faster, and to the advantage of every one, including the town lot speculator, the home owner, and the water department.

There would be no "log rolling" or favoritism as to where pipe should be laid first, but all would have an equal chance. People could have water just as fast as they are ready to pay for it.

Some time ago a lady called on the phone and wanted to talk to the Superintendent. She said the water at her house had suddenly stopped coming. It was explained that a connection was being cut in near by and the water would be cut off for two or three hours. In a tone of distress she said, "Why, I must have water; what in the world shall I do?" I jokingly told her I guessed she would have to go to the nearest spring as our forefathers did.

The water problem is a very human problem. There is no other utility which so intimately touches the life of the people of a city. The water supply is a vital part of their daily living.

As to light, for instance, there is a certain amount of independence. We can choose between electricity, gas, a coal oil lamp, or a tallow candle, but there is no substitute for water.

It is not mere hazy idealism to say that the nearer we approach a square deal in all human relations, the better for all in the long run, but it seems to me, this applies with special force to the question of rates and general management of a public water supply.

It has been common in the commercial world to "get the money" first, and consider the equity afterwards and incidentally. But the country seems to be feeling the impulse of a new civic conscience—new, at least in some of its aspects—which demands equity first and profits afterwards. Water works managers, it seems to me, have an unusual opportunity to promote this new spirit.

DISCUSSION

Mr. W. J. Spaulding, Springfield, Ills.: I fear this paper will be of very little interest except to those interested in municipal plants. I was led to write this paper because the subject is now being agitated in my home city, Springfield, Illinois. There is one redeeming feature, however and that is that it is short. I am in hopes that it may elicit some criticism and discussion, because otherwise the paper will be of very little value. We are now discussing the question as to what is the most equitable way of paying for water mains, and are trying to arrive at a wise solution.

A Member: I would like to ask Mr. Spaulding what he would suggest as to the method of handling this item of receipts for extensions received from property owners, whether he would charge that up to general receipts, or to the property account? You suggest that the property owner shall pay for the main; that being the case it amounts to an assessment.

Mr. W. J. Spaulding: We levy an assessment to cover the cost of the improvement, just as we do with sewers or pavements. When the sewer is laid the cost is estimated by our board, and the assessment is made on the cost proportioned amongst the frontage owners at a given rate per foot. The assessment is made against the property and becomes a lien upon it just the same as other taxes. There is no money raised except what is to be immediately put into the cost of the water pipe.

Same Member: Perhaps I have not made myself clear. The method of assessment is all right, but having received the money that goes into the fund, do you capitalize the cost of the work?

Mr. W. J. Spaulding: No indeed, the line becomes public property, and is also the property of the frontage owners particularly. That would not be capitalized as part of the assets of the water plant.

Mr. J. M. Diven: It would not go into your construction account?

Mr. W. J. Spaulding: No, sir.

Mr. A. A. Reimer: That is the point I had in mind. I feel that the water department should stand as an investment of the city entirely. I feel that we are in a stronger position when we control absolutely the whole system, barring possibly the service pipes leading into the property. But even carrying that out, you might control those also. In regard to mains, I think that as the cost of maintenace would have to come back on the city, unless Mr. Spaulding carries out his idea a great deal further than I think he would, the city should control the original cost and should capitalize that as a part of the system of water supply and distribution. I feel that it is a mistake to throw in any part of the system of water supply to the assessment account and not into the capital account. I think it should stand complete as a system. Take, for instance, the case of a private plant, if any such scheme can be worked out, with the coöperation of the city, whereby an assessment can be levied on the property owners, it would make a pretty bad feature in the case of any condemnation proceedings for the purchase of the plant at any future time, to have portions of that plant paid for by assessment, and part by the bonds of the company. I feel that our position is stronger as water companies in controlling absolutely the system, especially the general system—and possibly all the other details. We do not put any charge on the consumer. The only requirement that we make is, that a certain amount of money shall be guaranteed by prospective consumers—generally about 10 per cent. When the water receipts from the new line reach 10 per cent, that 10 per cent is done away with. We take such water receipts as come in after that time. It is not a hard and fast rule. I further recognize that, for the sake of the city at large, we should go ahead and lay the mains. We are independent of the general city council and are a separate board controlling a good deal of money; so we are able to go on developing these extensions where there is a reasonable expectation of revenue to be derived.

Mr. J. W. Ledoux: The point I was trying to make in my paper was, that a private water company as a usual thing cannot afford to lay an extension for ten per cent; if they do, they will be at a loss before they get through with it, because 10 per cent is barely enough to pay for fixed charges and not enough to pay for any water. They will have to have at least 10 per cent to pay for it, and then you do not get anything for serving the water at all. The practice of the concerns with which I am connected is, to require every first applicant for water to pay for the pipe, pay the entire cost of it; but in any case that pipe is donated to the water company, and usually there is a provision that when the amount of revenue reaches a certain amount some other provision is made.

Mr. A. H. Wehr: I want to relate an experience we had in connection with the extension of water mains. We operate in all the suburbs of Baltimore City, and probably have as many extension problems as any company is likely to have. For instance, during the year 1909, we extended our system to a greater or less extent into sixty separate and distinct suburban developments that were for the individual profit of the owners entirely. We have had a great deal of that coming along in past years, and it has always been a problem with us as to how best to handle the subject of extensions, till within the last two years we have worked out an average basis which seems to meet with the approval of everybody brought into contact with it.

In the early days of our company we figured on the amount of revenue that was immediately available on an extension, and made an investment which was equivalent to a capitalization of 20 per cent on that revenue, and required the applicant to pay the difference between that and the actual cost of the line. In the new developments where a considerable run of pipe was required, and where subsequently houses would be built, the applicant naturally did not see why he should pay that money to the company and not get it back. So we soon found that that did not work satisfactorily. Then we attempted an arrangement whereby we would figure the actual cost of the pipe, the cost that accrued on it on the basis of twenty per cent of the revenue, and gave them a refund equivalent to twenty per cent capitalization of the additional revenue as it came along until the applicant's money was refunded. Over and over again we met this difficulty—that in laying out our system we wanted at times to lay a six inch, eight inch, ten inch or twelve inch line, but for that particular purpose in any development a four inch line was ample for all present purposes, and the applicant objected to paying the cost of the six inch or eight inch line when a four inch was all he wanted, and would insist upon having a four inch line; so that in order to keep control of the situation, we worked it down to an average basis. I might also say that our experience was as stated in the paper of Mr. Spaulding, that as soon as water lines get into a development, the man raises the prices of his lots when the water is on. We tried the arrangement of attempting to hold him down to his price prior to the extension of the main for a period of two years. That did not work very well. So now we require the owner of the developments to deposit with us a sum equivalent to one dollar per foot of the main that he has laid, the mains to belong absolutely to the company. The company pays taxes and depreciation charges on that line; it does not pay interest on the amount of money which is deposited. The applicant for the extension is given immediately a credit of fifty dollars of the total amount deposited for each house which is constructed and ready for immediate connection; in other words, for each house which will immediately yield revenue; and the remaining money stays in the hands of the company and is refunded in installments once each year, on the first day of March, at the rate of fifty dollars for each house which is connected to that line and actually using water and paying in revenue prior to the first day of January. Of course the interest is carried by the man that has the development, in order to limit him as to the amount of pipe he wants laid, and also that his development may come along consecutively, and that he shall not work up the rear of his development and work towards the front. Any money that is not refunded to him within five years from the date of deposit is forfeited and remains the property of the company. In that way we limit the extension, because the man does not want more pipe laid than he feels sure that he can develop within five years, so as to get his money back. He sees that the only cost to him is the cost of the interest on the money which he puts up with the company. It gives him no control of the mains that he desires to lay; and the average cost where the street improvement is not yet laid is about one dollar per foot.

Mr. M. L. Worrell: I understood the gentleman to say that forty feet of six inch pipe would cost fourteen dollars?

Mr. W. J. Spaulding: Fourteen dollars for each side of the street.

Mr. M. L. Worrell: With us, when the main is laid down, every tap is paid for, and we make the subsequent connection free. I was raised with a private franchise company and only recently went with a city. Our method of procedure with the private franchise company—and which I advised the city to follow, and it is following—was, that when a development company wants to build up a section, want water and makes application for it, we pursue this method: the water company, or the city, undertakes the construction of the pipe line furnishing everything, and the development company pays every dollar of the expense—which includes no profit—and when that pipe line pays 25 per cent per annum of the gross amount of the cost of the pipe line, we take it over without interest.

Mr. W. S. Cramer: At Lexington, Kentucky, we are benefiting a great deal by Mr. Worrell's experience, and have followed his example very closely in the matter of extensions on the plan that he has spoken of. One thing that we have done in the matter that he touched upon, as to larger piping, we put the matter up to the development company and to a few different firms with reference to the four inch supply, as Mr. Worrell outlined it, calling their attention to the advisability of future fire protection, and with the understanding that for each fire hydrant ordered on each four hundred feet of extension we would take that main over and settle with them on a certain basis. On some of the more recent improvements we have allowed as high as an eight-inch pipe and they have paid for it. All the later extensions have been made on that basis.

Mr. William R. Young: Our city of Minneapolis is scattered over about fifty-three miles of territory. We have mains there running in sizes from sixty inch down. No trouble has ever existed on this subject as between property owners and the city water works. When a person wants water on a street where there is no water main laid, he makes application for it, and the service is run at his own expense, but he then waives the right to make any opposition to the laying of water mains there at any future time. He also agrees that when the water main is laid, as property is built in beyond him, that where it is necessary to open the street for connections or extensions, that it may be done. If there are one or two persons that want water their interests are considered more than vacant property owners. When a main is laid, the value of the main is taken and if it does not exceed $1.40 a foot, an assessment is made in that amount; but where the cost of the main exceeds the cost of $1.40 per foot, we are permitted by charter to charge $1.40, or 70 cents a foot on each side of the street. This money that we receive, which is about 40 per cent over the construction each year, is simply put in the revenue expense account and used as a fund for construction; and out of this fund, and also from the excess revenue from time to time, all our construction is provided for. During the last five or six years our construction in Minneapolis has run from eighteen miles to twenty-three miles of mains, all over six inch. This year it will run approximately twenty-five, and possibly thirty miles. At no time in my experience there in the last fifteen years has there been any objection as to the payment of these assessments from the property owners. Only a short time ago a man had a big tract of unimproved property, who objected to the charge, and he was asked whether the property was for sale. He said it was. Then the water main was laid. A few days later when I asked him about paying for that assessment, he acknowledged that the price of lots had increased twenty-five dollars because of the main having been laid, and the added value would amount to eighteen hundred dollars. Our construction has gone along harmoniously and happily in that way.

Mr. Alexander Milne: It appears that in some extensions the property owners are between the devil and the deep sea; first, he pays the cost of construction of water mains, then the assessor comes along and increases the valuation of the property because of the water main construction.

Mr. E. E. Davis: We have the rule in Richmond that where the party asks for an extension of a main, he signs a guarantee to take water within four months of the time of completion of the main, or we will not make the extension. For instance, say we have several blocks that want an extension made, the vacant lot owners sign for the water as well as those where houses are built; and the houses are immediately taxed and commence paying their water rent at eight dollars a year, so that to all the vacant lots, the names of the owners of which are signed to the application for the extension, whether they tap or not we send a bill of eight dollars a year, and we make them sign a guarantee to that effect. We make no extensions at less than 10 per cent of the cost.

Mr. Charles S. Potter: Being a municipal plant, we feel that we must extend within the city limits whenever we feel justified in doing it. Any one wanting an extension, whether he be an alderman or a humble citizen, takes out a petition which the property owners along the line of the proposed extension sign, and then an assessor is sent who carefully goes over the ground and makes an approximate estimate from the information at hand. If his estimate shows 10 per cent, then the extension is promptly laid.

Outside of the city limits, where they pay no taxes, although we are amply provided to give them water, we feel that it is an expense that should be borne by the subdivision company, and we draw up an individual contract for each extension, and demand of them that they make a deposit covering the approximate cost of our engineering department. We do the work and charge them, plus 10 per cent administrative fees. We furnish them water at regular city rates. If at any time in the future that territory is annexed, we agree to take that pipe back less a small depreciation for each year, thus refunding the cost. In the meantime they have got the water at regular city rates, and we have received the revenue. As to lines of pipe laid outside of the city limits, that is, independent lines that some gentleman spoke of, say two-inch lines, we have no trouble in having them connected to the city main, for the reason that usually their pressure is very poor. If such independent lines have been down for any length of time, knowing possibly that the pipes are leaky, if they want to connect we put them on the meter basis. The increased pressure is generally sufficient to induce them to change over from private lines to the city line.

Mr. A. H. Wehr: I would ask whether a consumer is obliged to pay for the repair and maintenance; whether he is under any penalty in the case of leaks, and to whom do you go to ask for pay for that?

Mr. Chas. S. Potter: All our contracts are made with the property owners.

Mr. A. H. Wehr: Do you collect pro rata from each if you have to repair or patch a special pipe?

Mr. Chas. S. Potter: After we lay the pipe we take care of it at our own expense.

Mr. William R. Young: I would state that we deliver water to everybody, to the smallest as well as to the largest consumer, at eight cents a thousand gallons, which is just as near cost as it can be.

Mr. W. J. Spaulding: The main thing in which I was interested in this paper was to bring out the equity involved; and so far I have heard nothing to indicate any disagreement as to the equity in the frontage owners paying for water pipe whether they use the water or not. Some one suggested that we catch the property owner coming and going. I do not know in what way, unless you might say that while he has had to pay his share of the cost of these improvements, he has also had to pay a little more in the general tax—which is true; but surely the owner would not consider it unfortunate that his property had risen in value on account of the fact that he had to pay a little mite more of the general tax. He certainly would not consider that a misfortune; he would consider it very fortunate, and especially so when the water main increases the value of the lot anywhere from twenty-five to one hundred dollars. So it seems to me that a real estate owner certainly would have no ground for complaint if he paid the full cost of the ordinary distribution. Of course, for a trunk line, or for a large main, I should think the water department should pay the extra expense or adopt an average charge for it; but as to the equity of the charge, that is what I was chiefly interested in discussing.

Mr. Edmund T. Sykes: I would like to ask Mr. Spaulding, am I correct in understanding that your city pays for street paving and sewer assessments?

Mr. W. J. Spaulding: Yes sir.

Mr. Edmund T. Sykes: If one is equitable the other is. If you re-pave streets you have to pay for it again. In our case we pay for it again; we pay direct assessments.

Mr. Willis B. Durlin: Our city receives no revenue from sewers, but the property owner is assessed because it benefits his property. A water main is a different proposition. The water department lays that main as part of its equipment, in the same way as the manufacturer buys his machinery to operate his plant. I think it would be just as much equity for the manufacturer to charge every customer a pro rata assessment on the cost of his machinery as it is to make the property owner pay for the cost of a street main. With us everything belongs to the water department. We lay the pipe absolutely at our own expense, everything inside of the curb. The property owners pay nothing except to lay their own pipes on their own private property and through their houses. Suppose a man comes in and wants a main extended we will say 500 feet from the nearest water main, we say, "Very well, it will be necessary for you to sign a bond that you will pay us an annual revenue, that the water department shall receive an annual revenue from your extension equivalent to 7 per cent on the cost of the investment." We figure a six inch pipe at about $1.00 a foot. For 500 feet that would be $500. Seven per cent on $500 is $35. That man must give bond to pay $35 a year on that extension. He can sign the bond himself alone or he can get the intermediate property owners to go on with him for whatever amount they wish. If his water bill amounts to $15 a year, then he has to pay $20 on the bond; that makes up the $35. Every connection that is taken off that extension between the original main and his connection is deducted from the amount of his bond. If another man comes on to that extension and pays $15 a year water rent, that reduces the first man's payment that much; in other words, he would pay his own water rent of $15 and only $5 on the bond. The next customer that came in would wipe out the payment on the bond entirely, and the first man would pay nothing but his water rent.

Dr. W. P. Mason: I cannot help but feel that the property owner does not pay for laying the gas pipes.

Mr. S. J. Rosamond: With reference to the allusion of president Mason to the laying of gas pipes without cost to the consumer, it seems to me there can be no equity in making the property owner pay for mains laid in front of his premises, because if not immediately, certainly very soon, the main becomes connected at the other end and becomes part of the whole plant. It is necessary to make the whole system complete, and not only brings water to the abutting lot, but brings water to the cross streets and operates as a trunk line to other parts of the city. I do not think there is any equity at all in building up the system at the expense of the abutting property owner for the benefit of the whole city.

Mr. Dow R. Gwinn: Some years ago a case was taken up from Blue Island, Ill., to the supreme court in regard to the right of a city to assess property for a water main. The supreme court held that the city had the right to lay a water main and charge it up to the abutting property. Then in the village of Morgan Park they tried to carry that idea still farther and include the building of a reservoir and pumping station, dividing up the cost to the property at so much per front foot; but the supreme court held that they had no right to do that, but they could assess property for a main adjoining it. That was pretty good authority from the supreme court of Illinois.

I am very glad to have the question brought up to-day. I expected Mr. Caulfield to get up and tell us how they do in St. Paul, but he does not say anything. Some years ago a man came in our office and objected very seriously to the water rate that we were charging him. He said he had a brother in St. Paul who bought his water very much cheaper than he did. I asked him about the franchise tax. He said they did not pay any franchise tax up there. I said, "I beg your pardon, I have a report from my friend Mr. Caulfield;" and I showed him they had that year collected $135,000 franchise tax, and that of course if the citizens of Terre Haute would contribute $135,000 a year towards the construction of water mains that would place us in a different position.

Mr. John Caulfield: Since the city purchased the works in 1882 there has been a law providing for an assessment of ten cents a foot for the first twelve years, with no limit as to the number of years. That assessment was made, or was afterwards reduced to a period of ten years, so that it makes $1.00 a foot for ten years. The majority of the water takers do not know anything about it; it is collected in the general tax, it saves considerable annoyance to them. Now we are not allowed to lay mains without a petition from the property owners. Property owners representing one-third of the number of front feet to be assessed must sign the petition. For parties wanting temporary mains we have a limit of ten cents a foot that we charge, and we own that temporary main. We make them also sign a petition. just put on file until it may be ten years later when the regular main is to be laid. We also have them sign a special agreement that if that temporary main should by any reason burst, or if the grade of the street is changed—probably most of these temporary mains are laid where the streets are not graded at all—in the event of such grading the property owner is responsible for any expense in connection with that temporary main. We are not supposed to charge for the pipe itself, and we claim we never do: we charge thirty cents for grading. We lay the main and connect the service pipe with it. We lay the service pipe always on the same side of the street that the permanent main will eventually be laid. So there is practically no expense in making the connections with the services.

Mr. W. H. Randall: I would like to find out what is the usage on this side of the line as to tapping a pumping main. We have taken in a large back country around about the city, and it so happens that some of our pumping mains pass through the section recently taken in, and the question has arisen whether to tap the pumping mains or not. We have been opposed to it always. I would like to find out what is customary on this side.

Mr. J. M. Diven: This is largely a local matter, depending on conditions. Where the force main is, as in the case of a direct pumping system—in which all of the mains are practically force mains—a part of the distribution system, it would, of course, be tapped. If the force main passes through the city to a reservoir the speaker can see no objection to tapping it, nor does he see objection to tapping a force main from the pumping plant to the distribution system in a direct pumping plant. It has been his practice to do so, and he has never noted any bad effects from the practice.

If the force main is an entirely independent line from the pumping station to a reservoir he would consider it best not to tap it, but would not turn down a customer that he could not reach from the distribution system.

While theoretically it would be best not to have any connections to the force mains, practically there seems to be little or no objection to them. But the consumer should understand the condition fully and be prepared to meet it; his service might, by reason of being tapped on a force main, be more irregular than if on the distribution system; the pressure might be much higher, or a number of conditions might be different from those prevailing on the regular supply mains.

The speaker had one case where the consumer insisted on being connected to the force main, though it was parelleled by a distribution main. The force main was conveying unfiltered water to the filter plant and the water was wanted for watering plants in a large green-house. This customer wanted both water and fertilizer at the same price.

But the speaker's opinion is that this is a question that each one must decide for himself, after considering all local conditions.

A Member: Several years ago, in making an examination of an Ohio city, and computing the sizes of the mains, I found a 28 inch main a mile and a half long that went directly to the reservoir, and there was a parallel line down the same street. I went to the engineer and asked the reason for duplicating the line. His reply was: "You will have to show me how water can run up hill and down hill at the same time."

Mr. A. H. Wehr: We have two pumping lines upon which the conditions are rather severe; one from the pumping station, operating under a head of 250 lbs., pumping into the reservoir, along the upper end of which line we occasionally have some trouble with water-hammer, which annoys customers. We have another line which goes from one reservoir to another reservoir twenty miles away; it is up hill and down dale with varying pressure; we have some trouble with water-hammer there likewise. We have relieved that by relief valves put along the line where we found the greatest amount of trouble, and have had no further difficulty with consumers. In cases of that sort we provide in the application a reservation that the company may require the installation of a tank at any time, in which case the applicant must take water in the tank and supply his fixtures from that tank.

Mr. W. J. Spaulding: I want to ask if any one here has had requests to lay mains in alleys in new additions rather than in streets, and whether they have done so or not; whether there is any serious objection to laying mains in the alleys?

Mr. J. M. Diven: In the city of Corning, N. Y., the mains are all in the alleys.

Mr. S. J. Rosamond: I have at times laid mains in alleys, but in view of the fact that the sewer lines are all in the alleys, the laying of water mains there was found to be undesirable, because the sewer lines are laid deeeper than water mains and are more subject to seepage and repairs than water mains, and it is often necessary to dig long trenches down to the sewers in order to take out a few broken joints, and there is liability of the earth sliding from both sides and carrying with it the water pipes. So it has been decided to be best to give the alleys to the sewer lines and put the water pipes in the streets. Recently we have adopted a new system of paving and parking. We have put from eight to twenty feet of park-way on each side of the street. We are following these park-ways now and keeping away from the paving.

Mr. J. W. Ledoux: Most every railroad has a great many water standpipes along the lines and sometimes in the city; and I think the practice of the best water plants and companies is to require them in every case to put up a water tank and take the water from the water tank in order to prevent damage to the water mains which arises from the shutting off of the water suddenly by the railroad water cranes. I think it should be an imperative rule adopted by all water companies to require the railroad companies in every case to use water tanks and take their standpipes from those water tanks.

EXPERIENCE WITH CEMENT MAINS AT RAHWAY, NEW JERSEY.

WILLIAM BISHOP

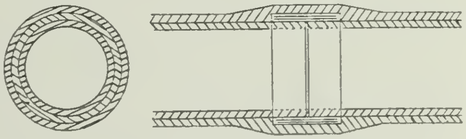
In every profession, conditions are met which render desirable, some method other than the usual standard; so in some places the use of cast iron pipe is almost prohibited by excessive freight rates, lack of transportation facilities, incrustation, or other causes, and frequent requests have been made for information concerning the use of cement mains, from those who have had experience with them.

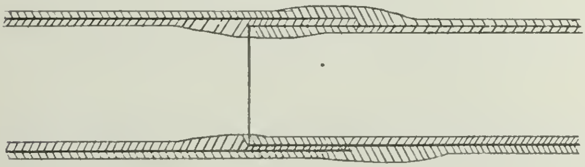
This information can be of little or no value unless the conditions under which the pipes are used, are considered.

In the years 1871 and 1872 about 12.6 miles of cement mains were laid in the city: the largest of these were twelve inch.

Each section of pipe is seven feet long and consists of a sheet iron shell riveted lengthwise, and lined both inside and outside with a coating of cement ½ inch in thickness.

The larger sizes of pipe are butt jointed with a short band at the joint, as shown below.





The smaller sizes are made with one end one inch larger in diameter than the other, and the small end of one pipe is laid inside the large end of the next, about four inches, as shown above.

About eighteen inches from the large end of the pipe a spud is placed with a lock nut on each side of the sheet iron shell; this spud is imbedded in the cement coatings sufficiently to cover the lock nuts, and is filled with cement also; a wooden block is put over it for its protection.

To make a tap it is only necessary to uncover the spud, drill out the cement, and attach the connection.

The usual pressure under which we operate is forty to forty-five pounds at the works, and as the city is comparatively level, the pressure is nearly the same throughout.

The pipe can be made to stand any moderate pressure by the use of a shell of proper thickness. In this particular pipe the shell does not appear to have been coated before being lined.

Until the year 1906 the pressure on the mains was direct from the pumps, since that time the water has been pumped into the standpipe which is close to the works, and that furnishes the pressure to the city.

The cost of the mains originally laid, including trench, filling, restoring the surface of the street etc., was as follows:

12″ pipe per foot	$2.07
10″ pipe per foot	$1.62
8″ pipe per foot	$1.32
6″ pipe per foot	$1.07
4″ pipe per foot	$0.82

There was at this time, however, very little paved street. The cost of that laid the following year was 10 per cent more.

For comparison, it may be stated the contractors offered to lay cast iron pipes at the same figures.

The repairs to the mains from the time they were laid to the first of the year 1910, including replacing about five-hundred feet through low ground with iron pipe, cost $6,235 an average of about $164 per annum, or $13 per mile per annum.

The twelve inch mains have needed scarcely any repairs, and experience has shown that where the pipe is properly laid on good, firm ground, with the pressure used here, there is very little trouble; where the ground is made or marshy, the pipes are more apt to settle and if the outside cement coating cracks, the air and moisture rust the sheet iron shell and eventually it breaks.

Strange as it may appear, sudden changes in the temperature of the water seems to have more influence on breaks than the change from direct pumpage into the mains to standpipe pressure has had.

When we have had to cut into the pipes, for any cause, we have found them absolutely without incrustation or deposit, and uniformly clean. The shell itself, with the exception of where the outside coating of cement was cracked, was as bright as it was when laid thirty-eight years ago.

Had cast iron pipe been originally laid, we would now be experiencing more or less trouble for want of proper pipe capacity, while to-day, although they were guaranteed for only 20 years, there is no reason to believe there is any general deterioration in the mains. Our water is considered an excellent one for boiler use.

REMOVAL OF IRON IN ORGANIC COMBINATIONS AT MOUNT HOPE, CANAL ZONE

JOHN R. DOWNS

Noting that considerable trouble has been occasioned of late in the removal of iron (in vegetable combinations), the writer takes the liberty of describing a problem of this nature, and a solution.

In 1907 two filter plants of the mechanical pressure type, were installed, one at Ancon to filter the supply of Ancon and Panama, and one at Mt. Hope to filter the supply of Cristobal and Colon. Each plant was of 1,500,000 gallons capacity, consisting of three half-million gallon units.

Both supplies were obtained by impounding small streams, there being a difference of some ten feet between high water (rainy season) level and low water (dry season) level.

Average analyses of the two waters are given for comparison. The albuminoid ammonia and iron contents give the only indication of any difference in filtering quality.

The Ancon filters care for the water from Rio Grande Reservoir with ease, even running at times considerably beyond their rated capacity.

The Mt. Hope filters on the other hand were absolutely useless under the load imposed by the Brazos Brook water, the filters clogging to the point of completely stopping the flow, in from one to two hours run (pressure 65 to 70 lbs.)

The writer agreed with a representative of the United States Department of Agriculture, that the failure of the filters under these conditions did not constitute a violation of the contract to furnish one and one-half million gallons of potable water from a normal raw water, as the raw (reservoir) water was plainly abnormal. Even the analysis of the water gave no idea of the actual filtering conditions.

Iron producing a high color, in combination with organic matter (vegetable extract), and some odor, were the chief objections to the water, its bacteriological character being good.

We, of course, turned immediately to the theoretical cure—aëration. But while this was effective in removing the odor, it had no effect on the filter load, failing absolutely to precipitate any iron.

The writer after experimenting with alum, lime, iron, permanganate, even copper, recommended the use of sulphate of alumina and sedimentation, other chemicals failing absolutely.

It was found that the iron was held in combination with the organic matter, and that this combination absorbed a large amount of coagulant. One grain per gallon of sulphate of Alumina consuming but 5.5 p.p.m. of alkalinity. Absolutely no precipitate could be produced in this water until 1.2 to 1.5 grains per gallon of $Al_2(SO_4)_3$ had been used. The amount varying with the condition of the water.

The minimum amount of coagulant which would produce a precipitate would invariably reduce the color to about 10 p.p.m. while 0.2 grains in excess of the minimum dose would produce a colorless water.

The volume of the precipitate produced under these conditions was incredible and amply explained the failure of the filters.

A reinforced concrete basin was built, having twenty sides. (The "sides" may better be considered as chords in a circle 100 feet in diameter) each chord being 16.5 feet long. A main center wall divides the basin into two equal parts, and three transverse walls, set equidistant at right angles to the main center wall, divide each half into four sections. An inlet chamber (7″ × 7″) is placed at one end of the main center wall and beside it is the pump well.

The water flows by gravity from the Brazos Reservoir into the basin, travels completely around the latter and back to the starting point (the pump well), from where it is pumped through the filters.

Communication between sections is by means of a four foot opening, full depth of basin, placed alternately at the periphery and adjacent to the center wall, causing the water to travel in all, about four-hundred feet. The basin is seven feet deep and holds about four hundred thousand gallons.

Weir walls with plank slots are provided, so that water can be made to flow in either direction from the inlet chamber. Intake wells are also provided at the opposite end of the main center wall from the inlet, so that either side may be used independently and both sides can be used together, either in series or parallel.

Both sides are usually used, in series, and at the end of a week the first two and one-half sections of the basin (an area of about 2500 square feet) stands six feet deep with precipitate (measured standing in the water). The water having kept open a channel about four feet wide (the width of the openings in the walls). Beyond the first three sections there is a uniform layer about one foot thick over the floor area.

Enormous as the bulk of this precipitate is, it is slimy and easily flows out with the water through two ten inch drains in each side of the basin. When about to clean the basin, these drains are opened, and when the water stands about four feet deep, men are sent in to keep the sediment stirred up. When the last of the water drains out, the final dregs are sluiced out with wooden pushers, push brooms and a stream from a hose.

Six men do the cleaning in from two to two and one-half hours. This time being so short and a stored supply of one-half million gallons of filtered water at hand, we find it more convenient to shut down entirely, instead of washing one side at a time.

Previous to completing the basin, an additional filter had been placed as the consumption had gone up to 2,000,000 gallons per day, but a trial showed that the additional filter without the the basin, did not relieve the situation in the least.

Since the basin has been in operation no trouble has been experienced in working the filters. We wash at intervals of twelve hours, as the limited capacity of the pumps make it necessary to keep the loss of head low.

About 90 per cent of the flock produced in the coagulating chamber is deposited before the water reaches the suction well. This would be too great a proportion under many circumstances, but gives an excellent result in this instance.

I will not go into details of construction, but mention one novel feature. A good storage space for chemicals had been provided in the filter house, convenient to the "pressure, alum-dissolving tanks" furnished with the filters. A convenient side hill provided an excellent location for the solution storage tanks, but was difficult of acess for teams hauling alum. We therefore connected a one and one-half inch copper discharge to the pressure dissolving tanks with a free delivery into the solution storage tanks, placed on the sidehill some seventeen feet higher. The inlet to the dissolving tanks is connected to a main under thirty-five to forty-five pounds pressure.

A weighed charge of sulphate of alumina is put into the pressure tanks and the water turned on. The entire charge is dissolved and carried up into the storage tank in one to one and one-half hour, the water being allowed to flow until a predetermined volume is obtained in the calibrated storage tanks—which hold twelve hours supply of solution.

From the storage tanks the solution goes through the usual head or float box. The orifice in the latter being circular (¾ inch in diameter) in a bronze plate.

We use a large orifice and large piping, with a weak solution, 5 per cent to 6 per cent and have no trouble with clogging. This would not be economical in large plants where enormous storage tanks would have to be provided.

The water being impounded, the changes in the character are slow, and we regulate the amount of coagulant by the strength of the solution, though it can also be regulated by changing the head in the orifice box.

The one trouble with this system is, that it involves the wasting of the basin full of water at each cleaning (once a week) This would be a serious matter in a large plant, moreover a basin of sufficient size to hold this precipitate for a week in a large plant, would be unwieldy.

After about the fourth day of operation, the organic deposit begins to produce some odor, and at times there is a slight increase in the bacterial count in passing through the basin. A week seems to be the absolute limit for leaving this deposit in contact with the water, after which a decided nuisance sets in, in the putrescible mass of slimy precipitate.

Ideal operation would call for the removal of this slimy putrescible mass at least every other day, and experiments were carried out using, as a settling basin a tank with an inverted conical bottom having a drain at the center, the bottom sloping 30 degrees from the circumference to the drain. These experiments, which will not be given here in detail, indicate that with the proper modification, tanks of this (the Kessel) type, could be used to dispose of the heavier part of the precipitate daily, with the loss of only such water as is actually contained in the mass of sludge. Such a plan has been recommended for another plant, now under consideration for handling a similar water.

An important point observed in treating this water is the absolute necessity for applying the full dose at one time, and immediate agitation of the mixture. A quiet flow of thirty seconds between the introduction of the coagulant and the agitation of the mixture is detrimental, one might almost say fatal to the success of the operation of this system.

It is worthy of note that the change from simple pressure filtration to filtration with sedimentation by permitting the use of sulphate of alumina in place of "potassium alum" has greatly reduced the cost of operation. The former contains 17.5 per cent alumina as against 11.25 per cent in the latter; and can be purchased at about one-half the price of the alum. This represents a saving in this particular case of $3084 per year, which would very soon pay for the installation. These figures are for filtering 2,000,000 gallons per day, and using an average of 1.5 grains of sulphate per gallon. The labor in this case was the same with either. There is also an additional saving in this case, as the alkalinity is so low, that "soda" would have to be used with Potassium alum at certain seasons. So far this has been entirely avoided with Sulphate of Alumina.

The plant has been in operation for nearly a year. When it was started, there was considerable potassium alum in storage, which was used before the sulphate of alumina could be obtained. This afforded a good opportunity for comparison.

No attempt has been made to make this a technical paper, and many details have been avoided, that the paper may not be drawn out. These details would probably never be applicable to any other case. Attached are three chemical data sheets for the comparison of the Brazos and Rio Grande waters for the past six months, and the Brazos water after filtration.

The Brazos water was dialized on June 11, 1909 when in its worst condition, with the following results:

Total Iron (Fe.)	3.4 p. p. m.
Passing dializer	2.0 p. p. m.
Not passing dializer	1.4 p. p. m.

Following table shows the increase in the number of bacteria growing in Agar Plates at room temperature—26 to 27 degrees C. —at stated times after cleaning the basin on May 21, 1909:

Days after cleaning	1	4	5	6
No. bacteria raw water	150	145	150	150
No. bacteria subsided water	30	325	450	375

Note: 26 degrees to 27 degrees C. is the average temperature under which natural bacterial growth takes place in this climate.

Rio Grande Reservoir.

	TURBIDITY	COLOR	ALKALINITY	CHLORINE	OXYGEN CONS.	NITROGEN AS				IRON	TOTAL SOLIDS	LOSS ON IGNITION
						FREE AMON.	ALB. AMON.	NI-TRITES	NI-TRATES			
1909												
Sep	7	10	57	5.5	2.6	.016	.128	trace	trace	.1	103	21
Oct	15	50	44	4.0	5.6	.044	.264	.001	.003	.4	100	27
Nov	10	58	40	4.5	2.8	.056	.220	trace	none	.8	96	14
Dec	15	20	39	4.0	2.5	.010	.212	trace	none	.2	109	28
1910												
Jan	7	40	45	4.5	1.0	.030	.180	trace	trace	.7	82	32
Feb	0	12	56	5.0	.8	.022	.118	none	none	trace	104	28

Brazos Brook Reservoir

1909												
Sept	30	74	26	6.0	5.3	.012	.444	trace	none	2.0	72	40
Oct	20	118	26	5.5	3.1	.008	.352	trace	trace	2.0	79	38
Nov	28	74	24	6.0	3.7	.008	.448	trace	trace	2.0	75	27
Dec	20	20	16	6.0	2.3	.010	.360	.005	none	3.0	80	36
1910												
Jan	20	20	16	5.5	2.4	trace	.270	none	none	.75	48	25
Feb	30	25	16	6.0	2.4	.014	.254	trace	none	trace	69	40

Filtered Brazos Water

1909												
Sept	0	5	4	5.5	0.5	.009	.088	none	none	0	77	22
Oct	No analysis in October											
Nov	0	0	3	6.0	.5	trace	.120	none	none	trace	84	16
Dec	0	0	3	6.0	.0	.012	.120	none	none	0	75	29
1910												
Jan	0	0	5	5.5	.0	.015	.080	trace	none	0	39	14
Feb	0	0	4	6.0	.6	.016	.084	trace	none	0	64	25

The organic matter referred to in this paper is amorphous or liquid (vegetable extract) algae growths have been negligible. On the other hand the Rio Grande water has at times developed large growths of various species of algae.

The writer claims no part in the design of the basin described. It was designed by the Staff of the Municipal Engineering Department.

THE DANGER OF CONTAMINATION OF WATER SUPPLY BY BACK PRESSURE FROM FIRE PUMPS

ALEXANDER MILNE

The writer first waives claim to the "discovery" of the above "euphonious" title, and regrets that its presentation by the member first selected was unavoidably prevented by his illness,

The topic is one that has been frequently in the mind of the writer for several years, and one which (while causing a good deal of anxiety at times) owing to rather limited experience he does not assume to throw any great amount of light on, the object in getting into discussion on the paper promised being to evolve, for his own and the general benefit, some definite method of overcoming and preventing the danger, where the existing conditions are such as to permit the possibility of such contamination.

In past years the installation of private fire protection systems, sprinkler and otherwise, in manufacturing and business premises has been largely increasing, and in many instances these private systems have as auxiliary to the local water works supply, "fire pumps" taking their water from rivers, canals, ponds or storage basins adjacent to the premises, which water is very frequently polluted to such an extent as to be absolutely unfit for domestic use.

Ordinarily the specifications for such private systems are prepared by the staff of the underwriters the specifications calling for one or more check valves in brick chambers, etc., on the pipe or pipes connecting the private installation to the water works mains (and no one will find any fault with the said specifications as to lack of detail); but in the majority of such private systems under observation the work is done and all material furnished by the general contractors, who if permitted will naturally purchase all such material in their best interests as to the "financial "end of the contract, frequently assuming that a check valve is a "*check*" valve under any and all conditions and as the proprietors of such premises have frequently but slight knowledge of this class of goods, the whole matter falls back on the water department to protect itself by having such regulations as will control the installation of all private fire systems connected to the mains, and having the power to pass on all material used, the location and setting of all valves, etc., with provision for systematic inspection, and power to shut off and disconnect at any time should it be proven that the private plant is in any way affecting the domestic supply to the detriment of the quality.

First, then, naturally comes the question, will any check valve close absolutely tight at all times for a protracted period against intermittent pressure at variable loads? and if so, what type of valve is best adapted for this class of service?

It may be assumed that all check valves are made of the so-called iron body, bronze mounted type, and there are many patterns of these on the market, the makers of which are quite willing to assert "their superiority" over the other fellow's, and divers (talking) points of advantage are often enumerated as "angle of seats," "all bronze parts," "rotary disc," "removable gates," etc., all of which may give proper results in a "shop test" lasting a few minutes, hours, or days where the pressure is applied to one side of the valve only, and all parts bright and clean. This was brought very pointedly to notice during the writing of this "article," when on making an inspection of a manufacturing plant, the check valve on the fire pump (against the water main) was found leaking badly (estimated 10,000 gallons per day) and of course the engineer in charge "*had'nt noticed it.*" In this instance the writer did the installation and purchased the valve in question, which he considered as embodying *all the good points* above enumerated. The valve was under a load of 90 to 106 pounds from the water main, the pump being run twice a week for lubrication to 75 pounds and otherwise only for fire. On opening the valve some scale was found in the body while the ring and disc were in good condition, and the valve was tight on testing out afterwards.

Had this valve, however, been placed on the main against the pump, and in the same condition as found on monthly inspection the condition of the domestic supply can readily be imagined, had the pump been operated for a fire or inspectors test, as it pumps from a source heavily loaded with sewage.

Very frequent examinations of all such check valves should be made for leakage, and the writer's method has been to tap the main between the check and post indicator valves, inserting a service cock, then by shutting off the indicator post valve and opening the service cock, the condition of the check can quickly be noted.

Without entering into any discussion of the merits of any make or type of check valve, and having formed rather strong views on the subject of such danger of contamination from experience with this class of service, in addition to the results of a series of workshop tests of such valves—made for the purpose of more clearly demonstrating the actual results under different pressures on both sides of the check, I can only say that the "POSSIBILITY" of even the best constructed check valve getting out of order and failing to work is *always present*, and having in view the grave conditions that might result from the pumping of badly contaminated water into the domestic supply for even a few hours or minutes, there is no room for discussion as to the danger of this class of connection to the water department at all times where the source of the supply for the fire pump is known or suspected to be polluted, and water departments should avail themselves of every other means of satisfying the needs of their consumers (and the underwriters if you can) before permitting any such connection to be made to the water works system.

DISCUSSION

Mr. E. M. Peck: We have had a rather interesting experience in regard to check valves as between polluted and unpolluted sources. I do not know but what I might preface my remarks by saying that I have absolutely no faith in a check valve We took up the matter something over two years ago, or probably in the neighborhood of three years ago, in regard to a number of such cases in our city. There were at that time about thirteen large pipes running to nine different plants, averaging from four inch to eight inch in size, and in which there was nothing but a single check valve between the highly polluted source and our city water supply, which is a very fine one, no bacteria. We brought this matter to the notice of the local board of health largely to get their moral support in the matter; they immediately pushed the water department to the point of sending an ultimatum to the different concerns and requiring them to have this device absolutely cut off; that is, that they must discontinue either one source or the other. The manufacturers immediately held a meeting, and their representatives waited upon the water commissioners and represented that it would be a very great hardship for them to have to do that. There seemed to be no way to get around it except at very great expense to the manufacturers, and their desire was to let them adopt a sort of middle course. The water commissioners were very loath to do this. I fought the thing to the last stages and took a rather decided stand on the matter. I did not believe that a polluted and an unpolluted supply should be permitted on the same premises; I was overruled by the commissioners in that regard and I presume that they had a good deal of right on their side. But about this time insurance men came forward with what is known as a double check device and wanted us to try it, give it a thorough inspection, and if found suitable to allow the manufacturers to adopt it. We did this, and a very fine device was installed. The crux of the whole thing was in the check itself; it was one of a special design made by a company in our city. There was a very large area in the seating of the clapper. It was arranged somewhat for testing, as the writer of the paper said that he checked his. Those checks were placed in a pit. In addition to the arrangement for getting down to them and testing them at any time or investigating them, there was an automatic alarm device attached. I do not think that that amounts to very much. We found that there was enough oscillation in the pressure to keep the thing ringing periodically so that it was not of very much use. They are tested once a month by a young engineer who makes that his business. The expense of all tests is borne by the manufacturers. They have been in operation for about two years. I believe in that time we have found one check in two different cases—but never two checks in the same system—which leaked a little bit. There was some foreign matter which had gotten between the seat and the clapper. At least once a year those valves are opened and whatever matter may have accumulated is cleaned out and the valves are repacked and put in thoroughly good shape.

Mr. Robert J. Thomas: Regarding this subject of Contamination by Back Pressure from Fire Pumps, I have in mind a city that had a rather serious experience as a result of contamination of its water supply by water pumped from a polluted source into a private fire service system, thence, through a defective check valve into the distribution mains of the city's water supply. It was estimated that 500,000 gallons of this polluted water entered the system before it was discovered. The period of contamination was between eleven o'clock Saturday evening and seven o'clock Sunday morning. No information was given to water works officials about it until the following Monday, when, in all human probability, the water had already done its mischief. Then it was only mentioned in a casual manner by the man who had charge of the private fire system, he claiming that it evened up accounts with the city for a large loss of water suffered by the city on a previous occasion due to a break in one of the private fire pipes. Any warning that might be conveyed to the water takers would have been too late.

Almost simultaneously with the knowledge of this unwelcome infection by polluted water came numerous reports of severe cases of dysentery and diarrhea. Within a few days thousands of people were afflicted with bowel trouble, and in due course of time, one hundred and sixty cases of typhoid fever developed. A law suit against the city, rising out of this event, is still pending.

What happened in that city is likely to happen in other places under similar conditions. Where a public water supply is connected with a private fire system filled with polluted water pumped by fire pumps at a pressure greater than that maintained in the mains of the public supply, serious consequences are liable to follow.

Check valves, supposed to act automatically and keep the other water back, are not, to say the least, absolutely reliable. In fact, from my personal observation, they are not to be depended upon. While visiting a valve manufacturing plant a few years ago, with other water works men, we examined a number of completed check valves on the shop floor, and every one of them could be manipulated by hand so they could not close, showing what was possible to happen in actual use, particularly after having some years service. Nearly all the water departments that I visited, reported trouble with leaky check valves.

One superintendent of water works told me that it was not an uncommon occurrence to get salt water in the city mains where it leaked through check valves on private fire lines supplied by salt water. One thing is certain, concerns owning secondary or private fire service systems are not particular where they get the water from or as to its quality. I knew one factory fire pump that had its suction in a well that was a catch-basin for all the water wasted in the factory, including the drainage from tanks used for all kinds of metal plating.

I would suggest that the superintendents investigate the source of supply of these private fire systems, in their own town, for themselves and then consider that between this foreign, and many times polluted, water and the public supply nothing exists to prevent accidental contamination but a more or less imperfect mechanical device. If you do this, you will be convinced that back pressure from fire pumps is a menace to public health, and that steps should be taken to speedily terminate all connections between your works and secondary fire systems. Prompt action on your part may be the means of preventing an epidemic of typhoid fever. With a full knowledge of the risk of contamination both from your own study and the experience of others, failure to act would be no less than criminal negligence.

Mr. Henry L. Lyon: We have had numerous examples of these connections in Buffalo, because all along the water front different manufacturers, elevators, etc., have taken suction from contaminated water for fire use. They have also tried to connect the regular city water supply to the same fire system, so as to use it in case their fire pumps broke down; and have wanted us to rely upon the use of check valves to keep the contaminated water out of our mains. That we have absolutely refused to do in every case, telling them that we would not rely upon any check valve they could furnish; and in every case we have compelled them to disconnect our water supply from any contaminated supply which they might use.

SUGGESTIONS AS TO WATER WORKS FOR FIRE EFFICIENCY

W. H. GLORE

The greatest difficulty as to the cause of insufficiency of water for fire extinguishment takes place at the early commencement of the construction of water works in small cities, which eventually become growing cities; in the installment of the water works plant. As an illustration, a city of 20,000 inhabitants as a starter would figure that 10,000 in the course of five years would be users of water, and on a basis of 65 gallons per day per inhabitant in nonmanufacturing towns this would be 650,000 gallons per day (twenty-four hours). A pump would be designed to pump this amount of water, having in view the duplicating of the pump at the expiration of five years, estimating that this would be sufficient capacity for all purposes. In this case it could be readily seen what chance the fire department would have in fighting fires. While the committee on water works might be of the best citizens, the best men in business affairs, and be perfectly honest in their interest, yet they would not have the practical knowledge of water work or its various usages, and would further lose sight of the fact that the capacity of any pump rated for twenty-four hours after being installed, that the greatest part of the consumption in the twenty-four hours would probably be consumed within four hours of the twenty-four, and during the time of the greatest consumption the fire department would be badly handicapped as far as the supply of water was concerned, no matter how efficient it may be in all other respects. All might be remedied if a proper pump be installed on this line, taking for illustration a city of 20,000 after the basis has been made, viz., 650,000 gallons multiply this by two as a factor of safety, making 1,300,000 gallons, then by four for fire purposes, making 5,200,000 gallons pump capacity, and in order to give further protection to the property it would be necessary to make calculations for the consumption of water with all the facilities at the command of the fire department and of all nearby cities that could possibly render assistance during a conflagration, these combined all for continuous work for twenty-four hours, the result would indicate the capacity of pump required to give service and a proper supply of water for the fire department in extinguishment of fires, at any rate the estimated capacity of 5,200,000 gallons in twenty-four hours should be the minimum for very ordinary purposes. The continuous twenty-four hours for fire department purposes should be the maximum. The latter would be a safe requirement for the city and fire department except that the pump should be duplicated for emergencies. Circumstances at different places might make some little differences for estimating the capacities.

EXPERIENCE WITH AND RESULTS FROM MUNICIPAL WATER SOFTENING

ALEXANDER POTTER, C.E.

Municipal water softening is still in its infancy. Early experiences in municipal water softening in America were not satisfactory, but through no fault of the principles involved.

The theory of water softening is not new. The theory of the softening of waters containing a temporary hardness, due to calcium and magnesium carbonates held in solution, by the presence of free carbon dioxide, was enunciated by Dr. Clarke, of England, some fifty years ago. The treatment of such waters consists of the addition of lime water or milk of lime, applied in carefully regulated quantities. The resultant reaction is the immediate union of the added lime and the free carbon dioxide, causing the precipitation of calcium and magnesium carbonates.

Waters possessing permanent hardness, as well as those which are contaminated by mine or factory refuse imparting to the water metallic salts and free sulphuric acid in solution, cannot be thoroughly treated with lime alone. This hardness can be most economically counteracted by the use of lime and soda carbonate. This principal is familiarly known as the Porter-Clarke method, and although it was suggested over fifty years ago, no other process has been invented to supplant it during all these years. There are a number of different water softening systems on the market at the present time. The principal advantage of one system over another is simply one of economies in the distribution and use of chemicals and the removal of waste products of the process.

So far in this country water softening has been employed in municipal plants only when, to use the vernacular, the cities employing it have been "up against it." This was notably the case in Winnipeg, Canada; Oberlin, Ohio; McKeesport, Pa.; and Columbus, Ohio. Perhaps no city has ever been in greater need of nor has had a harder problem of water softening than the city of McKeesport, and the author was fortunate enough to be retained to devise a plan for its solution. For at least six months of each year the water of McKeesport was fit neither for man nor beast, nor for any commercial purposes whatsoever, save, perhaps, for street sprinkling. So bad was the water supply at McKeesport that it was characterized in the United States Geological Reports as the worst water in the country. It was so bad that, notwithstanding confirmatory reports upon the plans proposed from persons qualified to judge as to the probable outcome of the treatment, money for the construction of the plant was appropriated reluctantly by the governing bodies. In fact, each time that the board of water commissioners applied to councils for an appropriation to carry on the work of construction, it was the signal for a tirade of abuse on the part of some members of councils against the throwing away of the people's good money for something that was sure to prove an absolute failure. By emulating the motto, "Keeping everlastingly at it brings success," we succeeded in completing the plant in record time under the greatest handicaps. So convinced was the author that the plant would handle the water satisfactorily even in its worst condition, that it was put into commission before its full completion. This was done because the river water was more highly acid at this time than at any previous time, and a test of the plant under such conditions was highly desirable.

An examination of the diagram accompanying this paper will show that the conditions existing during the first three months of the trying out period, viz: October, November and December, 1908, have not been duplicated since. During this period, also the water consumption in the city was so great, due to imperfect plumbing fixtures, which had been eaten out by the action of sulphuric acid contained in the untreated water, and to faucets left open in the vain hope that the quality of the water would thus be improved, that the plant was called upon to treat practically the full quantity which the plant was designed ultimately to treat.

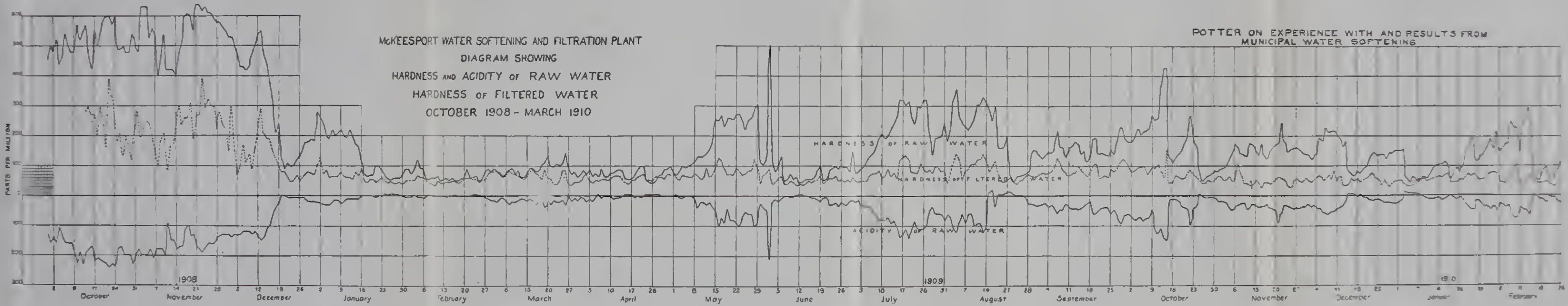
The high acidity in the McKeesport water is due to the large amount of mine water discharged into the tributary creeks of the Youghiogheny River, and to the spent acids from the galvanizing works along the shores of the Youghiogheny. The washings from the coke beds is another contributary cause Furthermore, the difficulties of treating the Youghiogheny River water have been increased during the last few years by the abstraction from the watershed of practically the entire flow of the Indian Creek, one of the main feeders of the Youghiogehny, and the transporting of this water for the benefit of the Pennsylvania Railroad into an entirely different watershed. The Indian Creek was one of the most permanent streams in the watershed, and the water from this stream went a long way toward counteracting the effect of the impurities in the river.

The acidity in the water for a number of years previous to the operation of the plant was as follows:

YEAR	AVERAGE ACIDITY	MAXIMUM ACIDITY
	PARTS PER MILLION	
1901	43.0	125.0
1902	42.1	200.0
1903	34.5	140.0
1904	50.6	170.0
1905	32.1	80.0
1906	28.0	120.0
1907	43.4	133.0
1908 October to December	150.0	240.0
1909	33.0	210.0

The acidity in the water since the plant was put into operation in October, 1908, is represented by the lowest curve on the diagram accompanying this paper. An examination of this diagram will convince the most skeptical of the variable character of the water to be treated. The water has jumped from a hardness of 110 at 4 o'clock in the morning to a hardness of 510 four or five hours later, and from an acidity of 30 up to an acidity of 210 during the same period. To produce a uniform product from the plant under such conditions requires the greatest care and watchfulness on the part of the employees of the plant. An examination of the curve of hardness of filtered water will indicate that a reasonably uniform product has been obtained.

The McKeesport plant was fully described by the author in a paper read before the Engineer's Society of Pennsylvania, and appears fully illustrated in their *Journal* for April, 1909. The



McKEESPORT WATER SOFTENING AND FILTRATION PLANT
DIAGRAM SHOWING
HARDNESS AND ACIDITY OF RAW WATER
HARDNESS OF FILTERED WATER
OCTOBER 1908 – MARCH 1910

technical weeklies have also described the plant at various times. It is therefore unnecessary to consume the time of the association with a description of the plant. Any one interested is respectfully referred to the publications mentioned.

Novel features of the plant which might be mentioned, and which a year and a half of operation have given a sufficient test, are as follows:

The method of cleaning the settling tanks without emptying them or interfering in any way with the continuous operation of the plant. Carriers are built under the floor of the settling tanks. The carriers in each of the four tanks are divided into four zones. Small circular holes seven-eighths inches in diameter, spaced four feet, apart connect the bottom of the tanks with the carriers. The outlet end of each set of carriers is controlled by a valve. In cleaning the basins, the valve controlling each zone is kept open until the precipitated solids are removed, and the water runs free from sludge. The amount of water used in cleaning the settling tanks and baffling tank is approximately 1700 gallons per day for each degree of hardness in the water, or approximately 400 gallons per million gallons per degree of hardness.

Another novel feature in the plant is the economic use of wash water. The entire machinery is operated by a water motor on the top floor of the softening building. The waste water from the motor enters the wash water basin for the filters. This water, charged against the plant as power, should not be charged as wash water, thus effecting a substantial saving. The amount of wash water shown in the annexed table is, however, the actual amount of water used in washing the filters, and amounts to 0.72 per cent of the total amount pumped.

Still another feature in the McKeesport plant is the arrangement for the entry of water into and exit of water from the the settling basins. The design of the plant allows the water to enter the settling tanks over a long weir with a relatively short travel through the tank to the long overflow weir, with a gradual reduction in velocity as it approaches the outlet weir. For a given capacity of tank the longer the weirs and the shorter travel through the tank to the overflow, the less the velocity, and consequently the greater the precipitation. The water as it leaves the settling tanks is perfectly clear and free from turbidity.

The character of the McKeesport water is so unusual that tables of cost of operation are apt to be misleading to other municipalities, because the persons seeking data of cost and practicability of water softening are apt to be swayed adversely in their opinions by applying to their own cases the costs of producing a softened water at other places, as for instance at McKeesport, without taking into consideration the possible differences in conditions between the water to be dealt with at different places.

The only fair way to analyze the cost of any particular plant is to weigh the cost thereof against the benefits to be derived therefrom. Bearing this in mind, we have on the one hand to consider, (*a*) first cost of plant; (*b*) cost of operation. As against this we must also consider, (*c*) the improvement in the water; (*d*) the decrease in operating expenses of the plant; (*e*) decrease in wear and tear upon the plant; (*f*) decrease in plumbing bills paid directly by private citizens; (*g*) the decrease in the cost of soap; (*h*) lengthening the wear of linens, flannels, and other fabrics; and (*i*) increase in the length of life of boilers.

Taking the case of McKeesport, the annual interest on the cost of construction is approximately $10,000.

The cost of operation for one year is $30,700.

The total cost of producing 4,000,000 gallons of softened filtered water a day is $40,700 per annum.

Against this we have the following saving.

Since the softening plant has been installed, the water department has dispensed with a number of its employees engaged on repaving curb connections whose wages, according to the president of the board of water commissioners, amounted to $15,000.

The private consumers expended annually in maintaining their plumbing fixtures over $35,000.

Since the softening plant has been installed, only 72 per cent of the water previously required is now pumped, thus making a reduction in the coal consumption of $6090 per annum.

The reduction in repairs of plant amounts to $3000 a year.

From the best evidence obtainable, the saving in soap and soap compounds alone amounts to over $10,000 a year, and the saving in the wear and tear in washing of fabrics of all kinds can be set down at $20,000 a year.

Summarizing these, we have, on the one hand, an added cost of treating the water of $40,700; and, on the other a saving, as enumerated above, of $89,090.

This balance sheet shows that the introduction of the water softening plant for the city of McKeesport, instead of being an added burden to the people, has proved to be a saving of $48,390 per annum.

As a side light upon the saving effected in the McKeesport plant, it may be stated that, before the water softening plant was put into commission, about 156 plumbers were at work in the city. Out of this number, only 46 were left four months after the plant was put into commission, and at the present time about the same average number of plumbers are employed in McKeesport.

In making the above comparison, the author has not touched upon the saving in life due to the reduction in typhoid fever, which has been quite marked, for he believes it is not altogether fair to take the difference in the death rate for the year before and the year following the introduction of such an improvement, and credit this saving of life wholly to the water treatment plant, because for such a comparatively short period there may have been many other causes contributing to the reduction of the death rate. It is fair to assume, however, that no one factor was more responsible for the reduction in the typhoid fever death rate than the water treatment plant.

Beside all these considerations, there stands out prominently the fact that the McKeesport water now has that palatable, crisp, fresh taste which is delightfully refreshing—a quality often lacking in public water supplies. The water is acceptable for drinking, cooking and bathing, alike. A greater cleanliness on the part of the people is also observed generally throughout the city.

The author presents herewith a table showing the characteristics of the water from week to week; also the amount of lime and other chemicals used in the treatmet of it, together with the cost of treatment.

The plant at McKeesport includes a filtration plant, which is in itself an interesting study aside from the softening plant.

During the summer of 1909, when the bacterial count in the raw water ran from 5 to 100 or 200, the bacteria in the settled and filtered water showed increases over the number in the raw water. The numerical increase in the bacteria in the filtered water over the raw water completely annihilated removal or efficiency percentages and did not present a very creditable showing. Furthermore, it was impossible to determine the character of the bacteria on any one day until two days later, consequently there was always a possibility, when the raw water contained baccili coli, of their passing through the filter as well. It is important to note also that so far as the reduction of bacteria is concerned, the filters failed to produce any reduction over the settled water. In fact, it is the exception rather than the rule, that the bacterial count of the filtered water is lower than the bacterial count in the settled water; all of which goes to show that, in a water similar to that treated at McKeesport, it is possible to dispense with the filter entirely.

Consequently, in October, 1909, the use of hypochlorite of lime was used at the suggestion of the auther, and has been in use ever since. The effect of the use of hypocholorite of lime has been to almost completely sterilize the water in the softening plant. The use of a sterilizing agent is a sufficient safety factor for destroying bacteria that would not otherwise be entangled and brought down with the precipitates in the settling basins. The amount of hypochlorite of lime used varies from two and one-half to twelve pounds per million gallons, and averages 4.0 pounds per million gallons. In the McKeesport plant, the hypochlorite of lime is admitted at the entrance of the baffle mixing tanks about one hour before the soda is admitted to the baffle mixing tanks. The hypochlorite of lime is dissolved in the coagulant tanks, and the coagulant pumps are used for the application of the hypochlorite to the water.

No coagulant has been used since the application of the hypochlorite of lime. A remarkable condition exists with the water at McKeesport, where with 450,000 bacteria and 1,500 turbidity in the raw water, no coagulant was used, and yet a clear water was secured from the filters.

In the opinion of the author, there are very many towns in which the introduction of water softening, coupled with the use of some sterilizing agent, would present the most satisfactory solution of the water purification problem, and be commercially more desirable.

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Water Softening at McKeesport, Pa., February, 1909, to March, 1910

Week Ending	Character of Water and Amount Used								Treatment of Water								Cost of Treatment of Water				
	Alkalinity		Hardness		Amt. F. W. Pumped Million Gallons	Wash Water			Lime		Soda Ash		Coagulant		Hypochlorite of Lime		Chemicals		Labor		Total Cost per Million Gallons
	Parts Per Million					No. of Hrs. between Washings of Filters	Amt. Per Day Gals.	% of F. W.	Per Day Pounds	Million Gallons Pounds	Per Day Pounds	Million Gallons Pounds	Per Day Pounds	Per Million Gallons Pounds	Per Day Pounds	Per Million Gallons Pounds	Per Day	Per Million Gallons	Per Day	Pe. Million Gallons	
	R.W.	F.W.	R.W.	F.W.																	
February 13	0	38	57	43	3.795	202	21,428	0.65	800	212	1,920	500	400	162	...	...	$24 00	$6.32	$37.27	$9.83	$16.15
February 20	+ 0.7	42	54	48	3.582	336	12,856	0.36	600	166	1,800	600	743	207	...	...	24.14	6.72	35.94	10.00	16.72
February 27	+ 1.0	47	65	56	3.516	336	12,856	0.37	914	261	2,186	623	1,186	213	...	...	31 69	9.02	29.91	8.49	17.51
March 6	− 12.0	51	80	74	3.484	252	17,143	0.49	1,000	286	2,700	773	686	196	...	...	34.68	9.92	29.49	8.44	18.36
March 13	− 17.0	58	75	68	3 464	252	17,143	0.50	514	148	3,086	892	400	116	...	...	35 69	10.32	30.76	8.82	19 14
March 20	− 21 0	46	99	72	3.462	504	8,571	0.25	3,057	885	4,114	1,190	457	132	...	...	55.11	15.90	31.12	9.00	24.90
March 27	− 19 0	31	107	57	3.917	168	25,714	0.66	3,000	918	3,857	984	171	44	...	...	53.53	13.65	29.67	7.57	21.22
April 3	− 10 0	34	76	52	3.007	144	30,000	0.82	3,543	980	2,443	676	1,200	333	...	...	41 99	12 50	30.94	8.56	21.06
April 10	− 2 0	27	72	53	3.600	202	21,428	0 60	1,714	476	1,800	502	800	222	...	...	28 86	8.00	30.49	8.46	16.46
April 17	− 1.0	22	72	54	3 645	144	30,000	0.80	1,371	376	1,671	458	571	157	...	...	24 97	6 84	30.51	8.26	15.10
April 24	+ 1.0	24	72	60	3.699	202	21,428	0 60	1,886	506	1,029	277	286	77	...	...	19.38	5.25	30.94	8.38	13.63
May 1	+ 1.0	22	79	65	3 490	202	21,428	0 60	2,314	671	1,157	331	800*	229	...	...	25.22	7.23	31 44	8.97	16.20
May 8	− 1.0	19	95	66	3 748	144	30,000	0 80	4,000	1,068	2,314	618	629	168	...	...	41.82	11.14	31.44	8.40	19.54
May 15	− 30.0	34	162	73	3.942	168	25,714	0 65	3,371	854	4,757	1,208	114	29	...	...	60.77	15.47	30.07	7.63	23 10
May 22	− 79.0	41	256	92	3.944	252	17,143	0 40	0,057	1,690	6,668	1,690	...	...	...	...	92.48	23.52	29.55	7.53	31.05
May 29	− 76.0	32	264	88	4 125	72	55,714	1.40	0,628	1,608	6,080	1,480	...	...	...	...	86.54	20 98	31.44	7.62	28.60
June 5	− 51.0	31	163	62	4.010	101	40,000	1 00	3,286	3,820	3,343	857	114	28	...	...	49.05	12.27	30 69	7.63	19.90
June 12	0	33	69	47	4.064	101	28,571	0 70	1,657	408	2,318	671	071	238	...	...	34 00	8.38	31.44	7.72	16.10
June 19	− 5 0	29	66	51	3.877	112	25,714	0.70	886	227	1,800	464	686	177	...	...	23 72	6.10	31.22	8.07	14.17
June 26	− 21.0	30	87	55	4.074	101	28,571	0.70	1,343	331	2,314	569	...	...	...	...	26.63	6.54	31.44	7.72	14.26
July 3	− 28.0	32	95	48	4 491	92	31,429	0.70	1,657	368	3,857	860	...	...	...	...	41.80	9.30	31.44	6.98	16.28
July 10	− 53.0	33	152	68	4.362	92	31,429	0.70	2,942	673	5,657	1,300	...	...	...	...	63.12	14.46	30.85	7.06	21.52
July 17	−101.0	32	250	86	4,614	63	45,714	1.00	0,429	1,400	10,019	2,170	228	49	...	...	119.40	15.84	32.72	6.88	32.90
July 24	−111.0	34	291	99	3.972	84	34,286	0.90	5,857	1,480	10,286	2,580	57	14	...	...	117.19	29.52	31.29	7.88	37.40
July 31	− 63.0	34	215	86	4.284	46	62,857	1.50	3,886	908	0,420	1,498	...	...	...	...	73.74	17.17	31.01	7.25	24.42
August 7	− 85.0	37	262	91	4 586	40	71,428	1 60	6,257	1,360	0,514	2,072	...	...	...	...	111.74	24 31	31.01	6.79	31.10
August 14	− 89.0	39	281	114	4 743	36	80,000	1.70	6,114	1,385	10,029	2,120	...	...	...	...	115.78	24.44	29.98	6.36	30.80
August 21	+ 4.0	32	119	70	4 478	46	62,857	1.40	5,857	638	3,600	805	772	172	...	...	49.10	11.02	31.01	6.88	17.90
August 28	0	31	69	56	4.374	126	25,000	0 60	1,886	431	2,314	529	578	132	...	...	32.29	7.35	31.01	7.07	14.42
September 4	− 29.0	31	139	71	4.210	40	72,214	1.70	3,600	851	3,871	918	...	...	...	...	49.65	11 76	31.01	7.34	19.10
September 11	− 41.0	25	164	91	3.922	63	45,714	1.20	4,000	1,020	3,857	985	...	...	...	...	51.31	13.08	31.01	7.90	20.98
September 18	− 35.0	25	152	81	4.091	72	40,000	1.00	2,400	586	3,343	818	...	...	...	...	40.05	9.78	31.01	7.58	17.36
September 25	− 49 0	26	157	78	3.034	59	48,571	1.20	3,257	827	4,629	1,178	...	...	...	...	55.20	14 01	29.49	7.49	21.50
October 2	− 68.0	26	188	100	3.819	56	51,429	1.30	4,857	1,275	5,400	1,420	...	...	...	...	68.76	17.96	29.98	7.84	25.80
October 9	− 81 0	23	220	88	3.530	112	25,714	0.70	4,287	1,214	6,687	1,890	...	...	...	...	77.96	22 03	31.01	8.77	30.80
October 16	−109.0	38	280	83	3.704	92	45,714	1.30	5,514	1,492	10,543	2,850	118	32	...	...	118.80	32.14	29.51	7.96	40.10
October 23	− 39.0	36	178	68	3.497	336	8,571	0.24	2,971	851	5,143	1,470	...	...	...	...	58.62	16.78	31.01	8.82	25.60
October 30	− 7.0	30	82	52	3.341	168	17,143	0.51	1,800	539	2,314	692	172	51	...	...	29.84	8.93	31.01	9.27	18.20
November 6	− 22.0	40	112	59	3.355	202	14,286	0.30	1,000	297	3,859	1,180	286	85	...	...	40 43	12.04	31.01	9.26	21.30
November 13	− 34.0	36	153	57	3.572	168	17,143	0.50	3,000	840	4,886	1,368	...	...	21	6	57.80	16.22	30.19	8.44	24.66
November 20	− 38.0	35	149	42	3.376	144	20,000	0.00	3,000	886	4,886	1,448	...	...	29	10	58 14	17.17	31.01	9.19	26 36
November 27	− 50 0	34	174	48	3 535	202	14,286	0.40	3,000	847	5,914	1,668	...	...	23	6	67.05	18.98	31.01	8.76	27.74
December 4	− 37.0	32	140	51	3 528	168	17,143	0.50	3,000	850	4,371	1,238	...	...	6	2	52.14	14 78	31.01	8.76	23.56
December 11	− 50.0	31	208	61	3.714	252	11,429	0.30	3 000	808	6,171	1,060	...	...	...	...	68 28	18.40	31.22	8.40	26.80
December 18	− 13.0	31	119	48	4 250	101	28,571	0.70	3,000	706	4,114	966	258	61	...	...	51.09	12.24	31.22	7.34	19.58
December 25	− 10.0	25	111	59	4 332	252	11,420	0.30	3.000	603	2,829	653	...	...	23	5	39.28	9.08	30.58	7.06	16.14
January 1	− 23 0	28	143	43	4.631	144	20,000	0.40	3,000	646	6,143	1,108	20	4	...	...	51.36	11.09	31.22	6.74	17.83
January 7	+ 5.0	29	82	42	4.387	101	30,000	0.70	1,571	358	2,314	628	714	161	6	1	31.62	7.21	31.01	7.08	14.29
January 15	− 8 0	28	78	58	4.442	168	17,143	0 40	571	128	2,057	463	257	58	26	6	24.91	5.61	30.68	6.90	12.51
January 22	− 6.0	34	89	58	3.894	202	14,287	0.40	1,286	330	2,314	592	457	117	46	12	33.85	8.69	30.97	7.95	16.64
January 29	− 27 0	28	140	64	3.965	202	14,286	0.40	2,600	656	3,600	910	457	116	10	3	46.22	11.68	31.82	8.03	19.71
February 6	− 38.0	32	168	67	3 716	144	20,000	0.50	3,057	823	6,143	1,382	...	...	10	3	59.59	16 04	31 68	8.53	24.57
February 12	− 50.0	32	193	65	4 063	144	20,000	0.50	3,514	753	6,171	1,516	...	...	10	3	70.34	17.32	31 82	7.83	25.15
February 19	− 30.0	29	116	50	4 286	120	25,000	0 60	3,029	708	3,857	890	...	...	14	5	47.58	11 12	31.82	7.43	18.55
February 26	− 13.0	26	81	41	4 135	168	20,000	0.50	1,457	352	1,543	373	...	...	20	5	20.38	4 92	29.25	7.06	11.98
Average	− 33.0	32.5	139	66	3 928	152	29,235	0 72	2,930	750	4.100	1,046	292	76	15.0	4.0	$52 95	$13 36	$31 16	$8 05	$21 41

It is to be hoped that this phase of the question will receive greater attention than in the past, for it at once makes commercially available the treatment of waters for other than purely sanitary purposes. There are so many cities throughout the United States and Canada afflicted with hard waters, that the purely commercial aspect of water softening must demand attention to a greater degree in the future than it has in the past. The benefits of a soft water are fully as valuable to the private citizen in the uses to which he puts his water supply as they are to the large manufacturing concerns which, it is well known, are being forced to install private softening plants for the preservation of their boilers, and the percentage of saving to the private citizen, by the introduction of softened water, will be found to be just as great proportionately as the saving to the manufacturer.

The average cost of chemicals at the McKeesport plant during the last year was as follows:

	PER TON OF 2000 POUNDS
Lime	$8.30
Soda ash	18.00
Sulphate of iron	11.00
Alum	12.50
Hypochlorite of lime	42.00

The character of the water at McKeesport perhaps requires the application of a greater amount of chemicals per million gallons than any other water in the country, and the satisfactory results obtained. should go a long way toward dissipating the somewhat prevalent idea that the use of chemicals in water treatment is injurious to health.

DISCUSSION

Mr. A. Prescott Folwell: I would like to ask in connection with some matters mentioned in the paper and also from what I have heard with regard to the Columbus plant, whether Mr. Ruttan has noticed any trouble in his town with the water meters due to any deposits in the water or to any of the chemicals added in the softening process. I might say that at Columbus they stated that they had found considerable trouble from the deposit of material on various parts of the meters in the houses at one time.

Mr. H. N. Ruttan: In answer to Mr. Folwell's question I would like to say that when our softening plant was first started up we had a good deal of trouble from the deposits of the carbonates of lime and magnesia in our meters and in other places where the current of the water was sufficiently slow to admit of the deposit. We made up our minds that that was due to our not allowing a sufficient time for complete reaction after applying the lime to the raw water, by which the water was allowed to get into the mains before the reaction had been completed. In order to overcome that difficulty a channel was designed covered with a perforated zinc top on which the water flowed from the filters and dropped like rain to the bottom of the tank below the zinc. Under the zinc and through the zinc a current of CO_2, was maintained, which was absorbed by the dropping water. In that way the water being supplied with an excess of CO_2, the lime was taken up and no further deposit occurred in the pipes. We have had no trouble whatever since adopting that process. The original trouble lasted only for about three months, and our plant was run for about eight years after that with perfect success so far as any difficulty of that kind was concerned.

It might be of interest to know why we shut down our softening plant. The plant was designed for a capacity of 2,500,000 Imperial gallons per day. It was kept going until our consumption reached an amount of more than double that quantity, and it was then a question as to whether the city should increase the capacity of the softening plant or shut it down, because it was certainly not satisfactory. The easiest way out of the difficulty appeared to be to shut down the old plant, and that of course was adopted by the council; although I have no doubt that our experience has been such that it will be only a short time before we will go back to softening our water supply. The cost to the individual householder was not more than two dollars or three dollars a year, while the cost of the hard water was probably from five to ten times that amount.

MR. J. M. DIVEN: That is in clogging up the pipes?

MR. H. N. RUTTAN: Clogging of pipes and particularly steam boilers, and household kitchen boilers and heating appliances. In glancing hastily through Mr. Potter's paper I notice that he says that the plumbers in McKeesport have decreased more than 50 per cent since this process was put in operation. I have no doubt that our plumbers in Winnipeg have increased 100 per cent since our softening plant was stopped. The use of hard water makes work for the plumbers; but I do not think that the rest of the community are inclined to stand it; the hardness of our water is about 400. We did not attempt to take out any permanent hardness of the water; we merely removed about 68 per cent of the carbonates of lime and magnesia. With that removal we found the water very satisfactory.

MR. A. A. REIMER: I noticed that there was an exclamation went around the house when the last speaker said 400. Did he mean 400 p.p.m.?

MR. H. N. RUTTAN: Yes.

MR. M. MILLER: We find that the trouble from precipitation arises from not giving the water time to properly settle. Especially is this the case with the sulphates. It takes less time with the carbonates. With the sulphates it sometimes takes four or five hours to allow chemical action and complete precipitation to take place. We find a certain amount of corrosion in our stand pipes and in fixtures in buildings that cause trouble once in a while. Since we put the water softening in general use we have done away with boiler makers. We have reduced the necessity for the employment of boiler makers about 97 per cent.

Mr. A. Prescott Folwell: There was another point that struck me as rather important in Mr. Potters paper. He called attention to the fact that bacteria were not reduced by this process but in some cases were increased rather than diminished. I believe that same result was found also at Columbus. There they observed occasionally that the number of bacteria would be two of three times as many in the effluent as in the raw water. At the Columbus plant they found that the bacteria were actually propagating in the lime deposits in the bottom of the tank—a peculiar kind of bacteria to which they did not give any name beyond stating that they were white bacteria which seemed to live in the lime and generate there in large numbers. If the lime was stored up it increased the rate in the effluent to a very high degree. Probably that is the explanation in the McKeesport plant, that it was not the original bacteria that came through.

Mr. W. F. Monfort: With reference to the increase of bacteria in the softened water, it ought to be remarked that that happens only within certain limits of temperature. In extreme cold or extreme hot weather that does not take place. This fact I do not think has gotten into print anywhere, that the most favorable temperature conditions for these bacteria is above and below ordinary summer temperature; so that you would expect that condition to arise in April, March or May; or if the season were particularly advanced at Columbus, I think it might come in February and from then on to April, and then disappear and crop out again. This particular breed of bacteria finds its most favorable conditions within the narrow limit of temperature which I have named.

Mr. C. Arthur Brown: The increase in bacteria is not always occasioned by temperature, inasmuch as the plant at Minot, N. D., taking water from an ice-bound stream showed a rapid increase of bacteria after passing through the plant. The water also in passing through this plant absorbs alkalinity from the alkali rock of the concrete of which the plant is constructed.

I think there is another thing to which the attention should be called of those who have not read Mr. Potter's paper, and that is that the conditions at Winnipeg and at McKeesport with regard to the plumbing proposition are somewhat different, the large plumbing expense incurred at McKeesport being almost entirely due to the amount of free sulphuric acid which the water contains and not to the ordinary hardness of the river water.

Mr. H. N. Ruttan: If any gentleman present is familiar with the subject I would like to ask how they account for the increase in bacteria after slow sand filtration? The Columbus plant has a very elaborate system of sand filtration, which under ordinary circumstances I should think should take the bacteria out of water. In our case water is absolutely free from bacteria when we start in with it. We do not use sand filtration.

Mr. Alexander Potter (*by letter*): The knowledge of any discussion upon the author's paper at New Orleans came to him only a few days ago. A copy of this discussion reached him on September 24th. The author regrets that he was unable to be present at the Convention in New Orleans, and also regrets that the discussion was not forwarded to him by the association, as there were many points brought out in the discussion to which he would have liked an opportunity to reply.

The author is informed that the Proceedings are ready to leave the printer's hands. He does not desire to delay their publication in order to be afforded an opportunity to reply generally to the discussion, but one point was brought out by Mr. Folwell which gives such an erroneous idea of the author's opinion as to what a softening plant can be relied upon to do, that a reply from him should be welcome, even though it should delay the publication of the Proceedings.

In discussing this paper, Mr. Folwell quotes the author as stating that in the softening process the bacterial count is not reduced, but on the contrary in some cases is rather increased than diminished. This impression needs correction. Nothing could be further from the truth than that the softening process does not greatly reduce the bacteria under all but abnormal conditions, as the following table of actual results for the month of March, 1909, will show:

March, 1909 Count After 48 Hours' Incubation

DATE	RAW	SETTLED	FILTERED	BACILLUS COLI	
				Raw	Filtered
4	700	00	00	None	00
5	125,000	1,600	00	“	00
6	2,500	00	00	“	00
7	200	100	00	Present	00
8	175	100	00	“	00
9	450	150	00	None	00
10	230	10	10	“	00
11	450	10	20	“	00
12	8,700	00	00	“	00
13	19,000	250	30	“	00
14	150	30	10	Present	00
15	90	00	00	None	00
16	100	10	00	Present	00
17	200	00	00	None	00
18	10	00	00	“	00
19	70	20	00	“	00
20	110	00	00	Present	00
21	40	00	00	None	00
22	300	00	00	“	00
23	70	10	00	Present	00
24	320	10	00	“	00
25	130	00	00	“	00
26	480	00	00	“	00
27	2,700	00	00	“	00
28	650	16	10	“	00
29	2,300	9	4	“	00
30	210	19	10	“	00
31	220	None	None	“	00

Since October, 1909, the use of hypochlorite of lime has produced a sterile water from the softening plant almost continuously.

ADVERTISING THE WATER WORKS BUSINESS

DOW R. GWINN

There are two distinct departments in the field of water works advertisements, the commercial and the educational. And yet, it seems to the writer that the latter must, in the very nature of things, be a help to the former.

In cities where every family and business house (or 90 per cent of the total number) must be a patron of the water works department or company, the average man would say that it is no use to spend good money for advertising space or matter. Maybe so. The writer admits that the possibilities are not as great from a commercial standpoint as in cities where only 60 per cent or even 70 per cent of the population are patrons of the water works.

The manager of a municipal owned plant will probably say that he has all the business and there is no use spending money for advertising. Assuming that the water works has plenty of water to sell and is furnishing most of the people, why not encourage the use of water motor washing machines. By buying these machines in large quantities, they can be bought for about $10 each. Where the consumer is supplied by meter, he can, ordinarily, get enough water for one washing for ten cents. Those who have used a first class water motor washing machine would not think of giving it up. The Monday drudgery of washing is relieved of most of its terror, where the water motor washing machine is used. The revenue may seem insignificant, but even at ten cents a week, it means $5.20 per annum and where 1000 of them are used at this rate, the gross earnings would be increased over $5,000 per annum. In some cities, a rate of $9 has been established for washing machines The point I wish to make is that the public generally does not know the advantage of these machines and in order to bring them to the attention of the people the columns of the local newspapers should be used. This is only one device.

Then there are communities that have not awakened to the advantage of the bathroom and some that have not yet reached the kitchen sink level. It is largely a matter of education, and by using advertising space these conveniences can be brought to the attention of the people. The successful merchant advertises freely; he creates a demand for his goods by the use of printers' ink.

By suggesting the convenience of a bathroom the housewife who is not provided with one begins to think about it; she reminds her husband that their neighbors have bathrooms—"why can't we have one?" He says something about expense, etc., but the wife sees the advertisement again and again. The idea that she must have a bathroom becomes rooted in her mind; she begins to save with the idea of getting what has been suggested by the repeated reading of an advertisement.

In some cities where small houses are built by the mile and cut off in three-room sections the real estate man does not provide bathrooms or even kitchen sinks. I am led to believe that by keeping the idea of a house with a kitchen sink before the reading public that it will not be long before Mr. Real Estate Man will realize that there is a demand for houses with kitchen sinks.

But one should not make the mistake of expecting that the insertion of one advertisement of water motor washing machines will bring the next day a lot of inquiries about these great labor-saving devices; or one or two advertisements of the convenience of kitchen sinks or the comforts of a bathroom will result immediately in a great demand upon the plumbers for prices. It takes time. It has been said that keeping everlastingly at it brings success.

The writer has not been successful in getting the newspaper men to write advertisements. The usual responses to a request is "you know all about the business and can present your case better than I can." So the writer when reading advertisements in magazines is on the lookout for material which can be used in water works advertisements.

So much for straight commercial advertising.

In regard to educational or good will advertising, there is much that can be said. However, it is the purpose of the writer to only touch the main points, and leave the subject for discussion.

It is hardly necessary for the writer to refer to the erroneous beliefs that are held by citizens of many communities in connection with public utilities. These erroneous beliefs are frequently the result of personal misunderstandings and lack of knowledge of the difficulties involved in supplying water service. Many men who are ordinarily conservative in their statements, are frequently very bitter towards a public utility. And, expressions of disapproval of water works management is not confined to private owned plants.

If the people who are so free to criticise the management of a water works plant, were informed about the business, its methods and its rules, the reasons for adopting them, its sources of supply, difficulties in securing water, the cost and problems in connection with purification, the perplexing question of securing men who will always be patient and courteous (even under abuse of customers) who will always say and do the right thing and will under all conditions, use good judgment; if they were informed and brought to realize that the difficulties in the water business are very much like those in their own personal affairs, the relations between the patrons and the managers of water works properties would be very much more agreeable.

The average man knows very little about the water works business; he has read occasional articles by theorists, the items in the local press condemning the management—maybe justly—but more than likely, without reason. Some one tells him that the rates in some other city are much lower than he is paying. Without considering the differences in conditions, he immediately jumps to the conclusion that he is being robbed. If the plant is owned by a corporation, he nurses a feeling against that company; he imagines that its prosperity is due to charging enormous rates for its service—that it is simply robbing the people.

And if the water works is owned by the municipality, he refers to the officers in charge as a lot of grafters and, secretly or publicly, decides to use his influence to have them thrown out of office at the next election.

A water works manager can not see each customer and explain all the details of the business, but he can buy advertising space in the local newspapers and spread the information over the entire city—at least among the reading portion.

Here is an extract from *Advertising and Selling* which may be of interest:

> That a street railway or lighting company should advertise in a community in which it enjoys an absolute monopoly still strikes many managers as absurd.
>
> The considerable number of managers of public service companies who have made an intelligent trial of it, however, take a very different view of the matter.
>
> Two distinct purposes seem to be at the bottom of the public service advertising movement—one to win the good will of the citizen and the other to increase business.
>
> Advertising has been surprisingly successful in overcoming an unreasonable adverse public sentiment in several cases in which it has been tried. Not only can a company, prompted by honesty of purpose, win that good will upon which successful retention and operation so largely depend, but at the same time it can materially promote business.
>
> The ill will that hampers a company in its plans is often due to ignorance, and can be changed to hearty support if the company will but take the public into its confidence.
>
> The average man of sufficient intelligence to contribute materially to make up public opinion is a reasonable being, and is willing to be shown. He does not expect the company to perform impossibilities, nor to operate without a fair profit. His favor is easily won and worth while. It is becoming recognized that a company has nothing to lose and very much to gain by a large measure of well planned publicity.
>
> Frank, straightforward statements of the aims, details and obstacles of operation, result in a better understanding, not only of the company by the public, but also in a clearer knowledge of the public and its many needs by the company and its executive employees.

The writer believes that it is easier to get business from an individual if you have his good will than if he did not know you, or is prejudiced against you.

By informing the public about your business, you will build up a feeling, a sentiment—call it what you will—that may have a value reaching into the thousands. For instance, take two water companies in two cities: in one there is a feeling of hate and prejudice due perhaps to the misrepresentations of some local politician who is making political capital at the expense of the water company. In the other city, the service may not be any better or the rates any lower, but, by means of publicity the people have been kept informed about the progress of the company, character of its plant, its methods, its plans for the future, and above all, its desire to treat the public fairly and squarely; and, suppose in addition to all this, statements of the earnings and expenses are published annually—who will say that the public sentiment made by such publicity methods is not a valuable asset? And, if the two companies were applicants for franchise renewals, which one would have the best chance of securing a reasonable contract?

The writer believes in publicity—in letting the people know about your business. With a first class water plant, furnishing good water and satisfactory service at reasonable rates, and with courteous treatment to its patrons, the management is missing a golden opportunity if it fails to keep the public informed. Truthful information about the plant and business, given to the public in the advertising columns of the local press, *is a safeguard.*

Some may say, "we are getting along all right," but, it was a great general who said, "In times of peace, prepare for war." The writer does not mean to advocate building two or three battleships every year, as it looks like a waste of money, but an occasional battle ship can be built so that other nations will know that we are not asleep.

To take a concrete case, the writer used advertising space in the Terre Haute papers to show our patrons that it was to their advantage, as a whole, to use meters; that the objectors to the meter system were in the minority and that the average occupant of a dwelling house could save money on the meter basis.

It is impossible to prepare a set of articles that will fit every case, as it is important to consider local conditions. The articles given were arranged by the writer for the conditions as they existed in Terre Haute in the Spring of 1909.

First, contracts were made with the advertising departments of the two leading papers for a certain amount of space at a certain price. It was purely a business transaction, and in buying advertising space, the writer knew that he was not purchasing the editorial opinions of the newspapers. It was planned to use about two articles per week.

The writer is now conducting a publicity campaign in a Western City which may be of interest to the members of this association. In this case, the articles were prepared by men who make a business of conducting publicity campaigns. A representative spent four or five days on the ground, gathering information and getting into touch with the local conditions. It requires good judgment in order to select from a mass of information that which will be of value to the average reader and, what is really of greater importance, *of interest.* The articles must be of interest, or those whom it is intended to reach will pass them by.

We decided that it would be best to use one page per week, using the Saturday night edition of the daily paper, also the same space in a weekly publication. By using large type and short sentences and confining the article to about 1000 words. we thought it would be more effective, than if smaller type and longer articles were used. We contracted for the necessary space, with the understanding that we were only buying advertising; that we did not expect to control the opinions of the editor except as our arguments convinced him; that we hoped to not only convince the public, but the editor as well.

In this particular case, we opened our vault to the Committee and they were allowed to see anything they desired. Furthermore, we advocated a provision in a proposed contract that the mayor should have the right to appoint a local taxpayer to represent the city on our board of directors. This was done with the idea that with full information about our business, the relations between the city and the Company would be harmonious.

Among the public utility companies who have conducted publicity campaigns, using advertising space for that purpose are the following:

Denver Union Water Co., Denver, Colo.
Spring Valley Water Co., San Francisco, Cal.
Scranton Water Co., Scranton, Pa.
Water & Electric Co., Kalispel City, Montana.
Water & Light Co., Nebraska City, Neb.
American Gas & Electric Co., New York, N. Y.
Gas & Electric Co., Oklahoma City, Okla.
San Diego Consolidated Gas & Electric Co. San Diego, Cal.
Pacific Gas & Electric Co., Phoenix, Arizona.
Muskogee Gas & Electric Co., Muskogee, Okla.
Fort Smith Traction & Light Co., Fort Smith, Ark.
Des Moines City Railway Co., Des Moines, Ia.
Indianapolis Gas Co., Indianapolis, Ind.

Of course, in buying advertising space, it is important to use it to the very best advantage; hence, the matter to be used should be given careful consideration.

After a good deal of personal experience, the writer believes that a straight advertisement, published in the advertising columns, with the name of the company attached, has more weight with the reading public than an article in the news columns which is supposed to have been written by the editor but which the average person knows was bought and paid for by the company interested. In other words, it is better to come out in the open and let it be understood that you are paying for the space and do so in order to give valuable information to the public.

It has been truthfully said that "people are bound to be interested in public utilities. They simply can't pay money to you ever day or every month without being interested in your company. If you do not give them the essential facts about your organization and your service, it is a certainty that some one else will try to do it for you."

The natural question that arises is, Does it pay? The writer believes that where a company is giving good service at reasonable rates, that its standing in the community will be materially improved by a wisely planned publicity campaign.

OPERATION OF SETTLING BASINS AT RICHMOND, VIRGINIA

E. E. Davis

The settling basins were put into operation on December 22, 1909, and the water first supplying the pumps from these basins was of fairly low turbidity and of fair purity; having been cleared and purified by plain sedimentation. Shortly after, or on January 3, 1910, the coagulating plant was put into service, since which time it has been in daily use.

I shall confine myself mostly to the records of March, this being the last complete month and the third consecutive month of operation; during which more work was accomplished and better results obtained.

The consumption of water varies daily, a difference of 3,000,000 gallons per day having been recorded since the plant was placed in commission. The largest consumption of water for any run in March was 13,965,000 gallons in 18 hours and 15 minutes. On account of the great variation in pumpage, the plan of 24 hours run was found to be impracticable and it was therefore necessary to abandon the same. A run is the filling and emptying of one of the lower or coagulating basins and the average length of a run in March was 21.8 hours, 34 runs being made during the month and a total of 403,498,000 gallons of water was sent to the pumping station, a daily average of 13,016,000 gallons.

The general condition of the James River water during March was good. Heavy rains around the first caused a turbidity of 880 parts per million, but in a few days the water in the river was comparatively clear and in the latter part of March a water with a turbidity of 8 was in the river. The gates which control the filling of the settling basins were closed during the muddy spell at the first of the month and not opened again until clear water was in the river. By the elimination of this turbid water, the cost of alum for the month was very much reduced and the settling basins contained during the month a water equal to the best that Richmond formerly received. In the latter part of the month when water with a turbidity of 4 was in the settling basins, it was treated with alum more for the purpose of purifying than clearing. The highest turbidity of water in the coagulating basins after treating was 6, the lowest zero. A reduction of 100 per cent in turbidity was obtained twice during the month. The average turbidity of the river water for the month was 74 parts per million, while that in the settling basins was 14 and in the coagulating basin 2.8. The average reduction for March in the water of the settling coagulating basins was 80 per cent.

The color of the river water was below normal during the month and the greatest removal of color after coagulation was 80 per cent. The average color for the river water for March was 12 parts per million, for the settling basins 12 and 3.2 for the coagulating basins. The monthly average reduction was 73 per cent.

The bacterial content of the river was high during the turbid period early in the month, but towards the end of the month lower counts were recorded. Not very high counts were obtained from the settling basins during March as only water of a low turbidity was admitted to the basins. Near the end of March water with very low counts was taken from the coagulating basins. The highest bacterial removal recorded was 95 per cent. The average bacteria content for the mouth of the river was 3,652 per cubic centimeter; of the settling basins 554 and of the coagulating basins 117. A monthly average reduction between the settled and coagulated water of 78 per cent was obtained.

The presumptive test for the Bacillus coli (intestinal bacillus) in the river water during March showed its presence in one-tenth cubic centimeter samples 16 per cent of the month, and in one cubic centimeter samples 67 per cent of the month. In the settling basins the Bacillus coli was not found in the one-tenth cubic centimeter samples and in the one cubic centimeter samples it was found 12 per cent of the month. In the coagulating basins the one tenth cubic centimeter samples were all negative and the Bacillus coli was found only in the one-cubic centimeter samples. A monthly reduction of 76 per cent in the settled and coagulated water was obtained.

The alkalinity of the river water was generally high during the month, except during the turbid period referred to above about the first of the month, and was not admitted to the settling basins. The alkalinity at this turbid period was 23 parts per million. The lowest recorded alkalinity in the settling basins during March was 29, on which day 1.2 grain of alum was used to coagulate the water, leaving a margin of 2.3 grain per gallon of alum that could have been used with no trace of alum left in the water. The lowest alkalinity of any water supplied to the pumping station in March was 19 parts per million.

The maximum cost of alum in any run in March was $25.65, the minimum $12.82, average $18.82 and the total for the month $640.14. The average cost per million gallons was $1.44.

Samples were collected daily from the reservoir and from a city tap, the difference in water before and after going through the distributing system being noted. The following results expressed in parts per million were obtained:

	RESERVOIR	CITY TAP
Turbidity	2	8.9
Color	3.8	3.2
Alkalinity	26	26
Bacteria per c. c	69	244
Bacillus coli "P. T." .1 c. c.	0	0
1.0 c. c.	0	3.2%

Samples were also collected at different hours of the day from 15 taps in various sections of the city, supplied by water mains which had been in use from 35 to 75 years. From the few samples taken it appeared that the age of the main and diameter above 3 inches has little to do with the turbidity of the water, the chief difference in turbidity depending upon the consumption. The greatest consumption doubtless occurs about seven o'clock in the morning when the pressure gauge of the Water Department is lowest and the examination proved the water to be more turbid in the pipes at this time than later in the day. The turbidity of these samples varied from 1 to 12, the one with a turbidity of 12 was secured from a 3 inch main. The color and alkalinity of all were the same, the bacteria tests made for three days from a tap on a new main showed up much better than the tests on an old main.

It must be remembered that this plant is still in its infancy and that many experiments and much additional work along the lines mentioned above will be necessary.

From the monthly bulletins of the health department of Richmond for February, the following is extracted: There have been 7 cases of typhoid fever reported during February, against 25 during February 1909, and 39 in February, 1908. This is a remarkable reduction in typhoid fever which is largely due to the improved water supply. An equally great improvement was recorded in March.

After many, many years of untiring observation and study of a large number of plans for the clarification of our river water, which was pronounced on numerous occasions, by different expert chemists to be the most wholesome obtainable for domestic purposes, and with the expenditure of much earnest effort and the experience of sad disappointments, we have at last succeeded in securing the means whereby we can eliminate the one and only objectionable feature of the water. Our energies were not spent in vain, but we have been generously rewarded and now, after bearing with the muddy water for 80 years with a patience akin to Christian fortitude, it is, with a spirit of much pride and a feeling of gratification that we can point to the result of the successful operation of the basins, its product of pure and beautifully clear water.

Our citizens so long accustomed to the water of the past, did not seem to grasp quickly the significance of the great blessing, but as the crystal current has continued to run through their faucets without interruption, the apparent idea thay entertained of a failure has been dispelled and from the expressions of praise and gratitude, it would appear that they realize fully the possession of "a thing of beauty" and of which I apprehend no doubt, "a joy forever."

Though lost to sight; yet to memory dear,
Mud
James River water is now brilliant and clear,
For lack of mud
The laundrymen are all wearing a bright smile,
The washerwomen are singing, the hours to beguile,
And all of them saying it has been only a little while,
Since we had mud.

QUESTION BOX

No. 1: "In many cities it is now the custom to use coagulants and precipitates to clear and clarify the water for domestic use, and in many such places large amounts of the waters so treated are used for steam making purposes, such as feeding boilers used in power plants. What is the effect upon these boilers of continuously feeding them with water so treated? Does it appear to corrode them very much, or otherwise prove injurious to them internally? Does it result in their scaling badly? What is considered the best preventative?"

Mr. M. Miller: It depends upon what they use as a coagulant. We are using a coagulant all the time to prevent scale. Water carrying a large per cent of mud may be treated with ordinary lime as a coagulant, which is cheaper than alum; we then take down the solid matter mechanically.

Mr. M. L. Worrell: I will not try to answer the question, but I will state that I do not find any complaint from the steam plants, and we use soda ash and alum in the mechanical filtration of water. We have some sixty-five steam plants, and as they make no complaint I guess we are doing no damage.

Mr. J. M. Caird: It seems to me that that question cannot be answered, because you have to consider each case on its own merits. You cannot lay down a hard and fast standard that will apply to all waters alike. It will not work.

Mr. O. F. Reynolds: That all depends upon whether or not the treatment is handled intelligently, and what the water is originally. I know of a case in Kansas where they have a very nice plant, nicely arranged, and the superintendent left some of the men in charge of the plant with instructions as to how the water should be treated. He had various testing arrangements there, installed by a consulting engineer, and he instructed them to follow it out with tests. But after the new man had been left in charge for a month or so he tested the water simply by looking at it, claiming that he could tell about how much lime and about how much soda ash was needed; consequently some days the water was hard, and other days it was soft. We are compelled to treat that water after it leaves the water works, because every time the water varies it puts us out of commission.

Mr. M. Miller: We are putting in treatment plants to treat our water all over the country. On one division of our railroad, 333 miles, the total amount of scale removed in the year was 515 tons. That came from four locomotives. We had one place in Kansas where we had a short line running down to Great Bend, about fourteen miles long. We kept two engines there, running them alternately, and while one was not running we would get to work on it removing the scale. We put in a treating plant, and one of those same engines is now running, and after four years of service we do not have to take the flues out oftener than once in sixty days.

Mr. J. M. Diven: We have practically soft water. The railways complain of it pitting the boilers, which I believe all soft waters will do. At Savannah they have a scale-forming water. The engines running between the two places have no trouble, because one water counteracts the other. The engines in the yard at Charleston have to have tubes renewed at short intervals. The switching engines at Savannah are clogged up in about six months.

Mr. M. Miller: In deciding the location of a mechanical treating plant we always take into consideration the character of the water at the different cities; that is, one may have water of one character in one city, and another in another; and at the intermediate stations we figure on the treatment corresponding to those stations.

We find that our treating plants save 60 per cent of the cost of the plant in a year.

No. 2: "What experience have you had with calking lead joints in cast iron pipe with pneumatic hammer?"

Mr. M. Miller: I tried that about two years ago, and split every bell.

Mr. Alexander Milne: I have been for the last six or seven months watching a construction plant where a pneumatic hammer is used entirely. The superintendent assured me that they had not split one bell, and that up to the fifteenth of March they had not had one leak. I examined the work in person and examined the joints afterwards, in fact got down in the trench and tried them with a four-pound calking hammer and ordinary calking tool. I certainly found that they were well driven. The additional factor in the pneumatic hammer was the saving in the excavation of rock for the bell holes, which was more than the cost of labor in calking would have been if done by hand. It struck me very favorably. I intend to put in a pneumatic plant for my twenty-four miles of work this year, laying ten-inch pipe.

No. 3: "Experience with the use of oil for fuel, its cost based on horse power developed, evaporation, or per million gallon pumped one foot high, making comparison, if possible, with the same work done with coal."

Mr. M. Miller: Compared with producer gas, I believe it is away below a producer gas plant in cost. A plant of 12 or 15 h.p. was run thirty days without stopping, at Madison, Ill. We have been making some experiments with gasoline and coal. We found that to produce 1 h.p.hr., with coal at one dollar a ton, was about equal to gasoline at ten cents a gallon, seventy-two tests were made.

Mr. E. S. Cole: You might correspond with an electric light plant at Westerly, R. I., where there are three 200 h.p. Diesel engines operating very successfully.

Mr. A. Prescott Folwell: There is one at South Norwalk, Conn., too, I believe.

No. 4: "Experience with different kinds of services, such as galvanized iron with short lead connection, all lead, lead or tin-lined iron pipes, brass pipes or any other material."

Mr. E. E. Davis: We have services in use that have been in since 1832. I do not think anybody else here can claim that record.

Mr. J. D. Barneti: In the south of England pipe was laid two thousand years ago which is still *in situ*.

Mr. J. M. Diven: That is about as long as any of us will care to follow out the record, but the question is interesting. Personally I have used both galvanized iron and lead. I know that lead will last almost indefinitely; the life of galvanized iron depends entirely on the character of the water and soil.

No. 5: "Experience with pipes laid in salt marsh. Have any pipes suitable for this service been found.?"

Mr. E. E. Davis: I have about four hundred feet of six-inch pipe laid in salt blue marl. It has been laid about twenty years, and is soft enough to whittle with a knife. The surface drainage that comes from the hillside gets mixed with this blue marl. We had a contention as to what was the cause of it, as to whether it was electrolysis; but the railroad track is two hundred and fifty yards from it.

Mr. A. A. Reimer: I can refer back to the time when I was in the railway work. At that time I had a long suction line of eight-inch pipe which was laid in clay and ashes, it was not just marl or clay, but there were some cinders mixed with it.

That pipe was guaranteed to go out of service about every six months regularly. It was a very heavy expense. After it went out the second time I went to the river from which we drew our boiler supply and scooped out several hundred loads of the river muck and put them in the bottom of the trench, allowed it to dry out a little, and then re-laid with new pipe, and covered it all around and on top with the river muck, and from that time there was no more trouble with it. I think the trouble was a combination of chemical and electrolytic action. After putting in this river muck we found there was no trouble either from the marl and cinders or electrolysis; it seemed to act as a perfect insulator. I was there perhaps two years after I laid it, and at that time it seemed to be as good as ever. Whether it still stands I cannot say. I have not seen it for five years. That was cast iron pipe.

Mr. S. J. Rosamond: Where a pipe line is already in, a shield of good Portland cement would probably protect it. From what I know of cypress, I think I would use cypress stave pipe in soil of that character. Several years ago I lived in a cypress country. Great quantities of cypress were being taken out of the swamps and cut up into shingles. It was remarkable the age of some of those logs that were lifted out of the swamp. No doubt they had been there for a hundred years or more; but those logs could be put into use and make as good shingles as new timber. I believe that if I had a pipe line of that kind to lay I would certainly use cypress stave piping.

Mr. A. H. Crowell: We have laid mains over salt marl. They have been down some seventeen years. We have trouble every two weeks, six weeks or six months in connection with that pipe. That can be overcome by putting the pipe on the surface; but there is no cure or help for the mains that are already in. One of the peculiarities that we have discovered is that after softening, you can take a length out and expose it to the air for from four to six months, and the metal will harden up and apparently be sound solid pipe. Another peculiarity is that it is only affected on the top or near the top of the main, never on the under side of the main. A second main has been there five years and as yet has not been affected in the least, but it is only a question of time. I would like some cure for that without raising the main. The only proposition I have heard is to raise it above the surface. At the time these mains were laid the city bought the right-of-way, and the owner would not consent to that. We are up against this softening question, and we cannot find a remedy.

Mr. W. F. Monfort: As to the action on the top of the pipe when salt is present, that looks like a case of electrolysis, due to the excess of oxygen in the soil near the surface. It is very interesting and from a theoretical standpoint I doubt very much if there is any remedy for it except to keep out the air from whatever source, or else get rid of the salt water. It looks as if it were inherent in the nature of the beast.

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"Pioneer" Asphaltic products have been specified by leading Engineers since 1896—*and they have never disappointed.* They have withstood the crucial test of practical use so successfully that Engineers have designated them as the *highest grade asphalts known.*

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will give the highest satisfaction always. Engineers everywhere are invited to ask us for evidence of the *proven merit* of this material and of our

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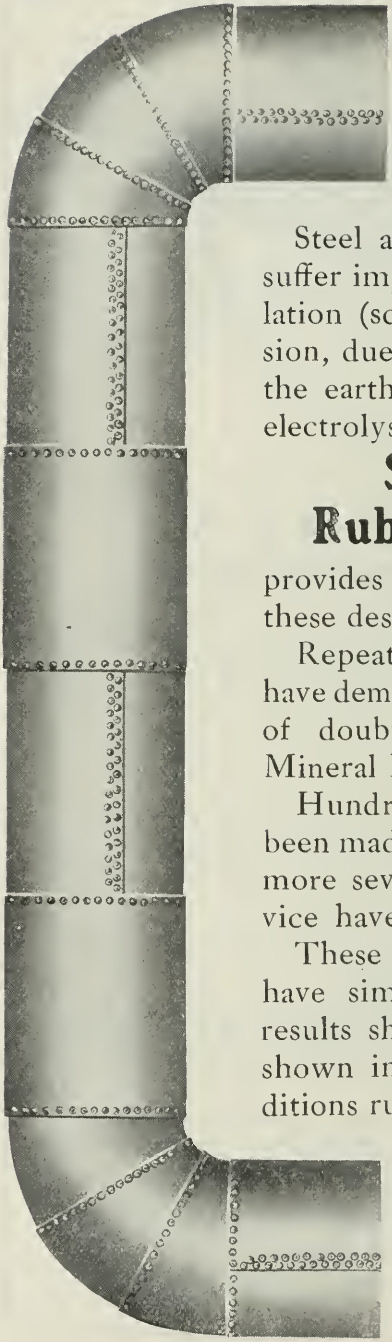

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Steel and cast-iron water-pipe lines suffer impaired efficiency by tuberculation (scale) from within, by corrosion, due to moisture and the action of the earth salts, from without, and by electrolysis.

Sarco Mineral Rubber Pipe Coating

provides the best insurance against these destructive agencies.

Repeated examinations of pipe lines have demonstrated, beyond the shadow of doubt, the efficiency of Sarco Mineral Rubber Pipe Coating.

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Sarco is a manufactured product of which "Gilsonite," the purest form of Asphalt known, is the base.

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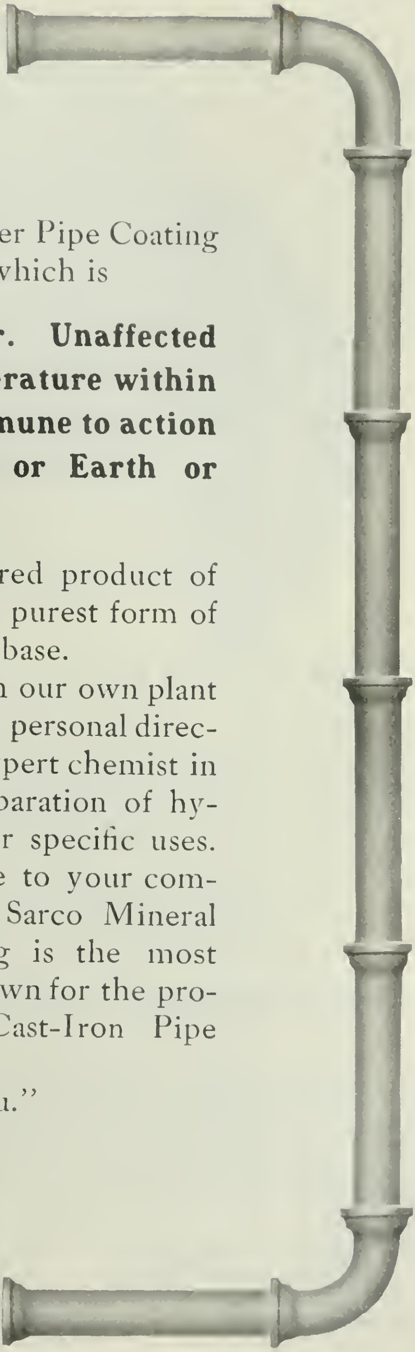
Ask us to "show you."



& Rubber Co.

Chicago, Ill.

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CYLINDER OIL
MANUFACTURED
ONLY BY
E. H. KELLOGG & CO.
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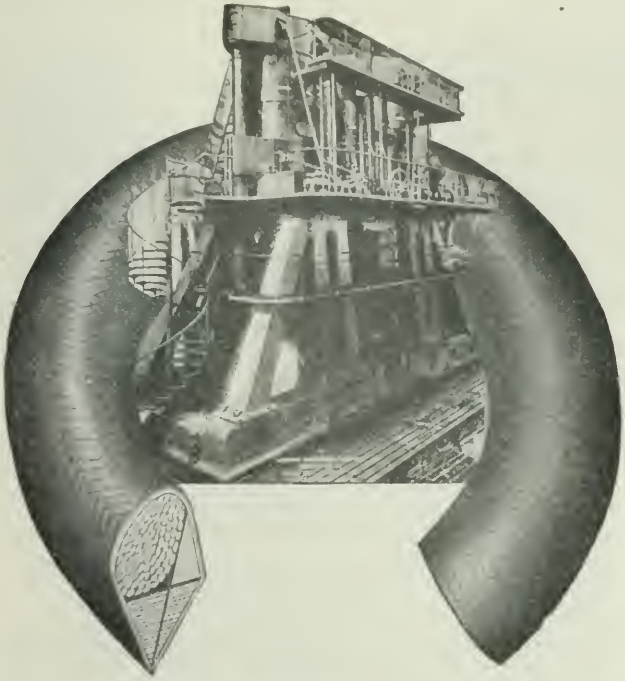

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CANCOS METAL POLISH

"best ever" for polishing all kinds of metals, hot or cold. *Sample sent on request.*

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37 Franklin Bldg., Baltimore, Md.
105 Market St., Pittsburg, Pa.
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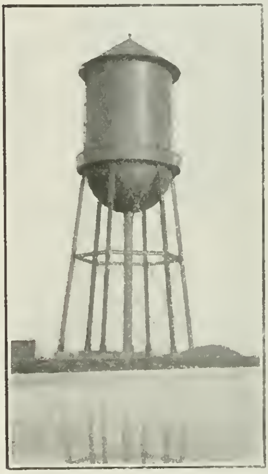
Elevated Steel Tanks

For

Waterworks Systems

THE following figures show the cost of fuel for pumping at the Washington Heights Station of the Chicago Water Works for a period of five years, during which the plant was operated by direct pressure, and by pumping to an elevated reservoir.

These figures show the saving in fuel alone accomplished by the latter method, the saving in wear and tear on the machinery and mains is inestimable.



Homestead Water Works
Cap. 200,000 Gal.
Height 100 Ft.

Years	Million Gals. Pumped	Billion Foot Lbs.	Total Cost of Fuel	Cost per Billion Ft. Lbs.
1899	107.7	98	$1453	$14.82
1900	118.2	100	2345	23.45
1901	139.1	94	2852	30.50
1902	157.2	187	2028	10.84
1903	243.7	290	2508	8.65

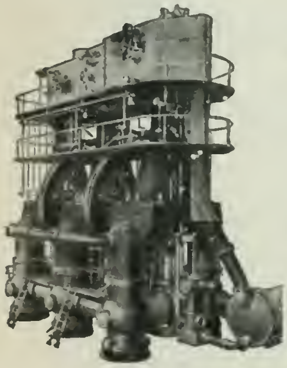
Note: During 1899 and a portion of 1900 a wood tank was being used. This leaked so badly that it was abandoned and the system operated by direct pressure until January, 1902, when a steel tank was put into service.

These figures were compiled from the monthly reports covering the entire period.

Chicago Bridge & Iron Works

Main Office, 105th and Throop St., Chicago, Ill.

Branch Offices	Shops
No. 30 Church St., New York	Chicago, Ill.
Praetorian Bldg., Dallas, Tex.	Greenville, Pa.



The Waterworks Plants of the largest municipalities in America are equipped with Allis-Chalmers pumping machinery

These include:

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Chicago
Philadelphia
New Orleans
Kansas City
Pittsburgh
Washington
and others

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GENERAL OFFICES—MILWAUKEE, WIS.

THE DARLING PUMP & MANUFACTURING CO. LTD.

WILLIAMSPORT, PA.

Manufacturers of DARLING Patented Gate Valves, Fire Hydrants Valve Boxes, Indicator Posts, Floor Stands, Water Works Supplies

THE PITOMETER COMPANY

THE "TEST" PITOMETER is now being sold for practical use by managers of works

AUTOMATIC RECORDERS rented by the month where continuous record is wanted

SLIP INDICATORS installed on pumping engines

220 BROADWAY NEW YORK

Mention

Proceedings American Water Works Assaciation

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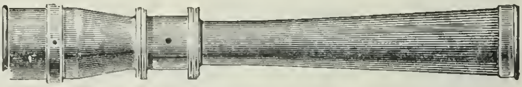
IT HELPS IN SECURING ADVERTISING BUSINESS NEXT YEAR



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from 2" diameter to 96" diameter have been installed
in the principal **Municipal Filtration Plants**
throughout the world for accurately measuring one
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Effluents from Each Bed	**Coagulant Solutions**
Wash Water	**Feed Water for Boilers**

Full information upon request

BUILDERS IRON FOUNDRY, Providence, R. I.

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WORCESTER, MASS.

Rotary, Disk and Current Type
of Water Meters

WATER AND STEAM PRESSURE REGULATORS
THAT POSITIVELY REGULATE

Corporation Curb and Waste Cocks

Extra Heavy Hand Ground and Guaranteed Tight under any Pressure

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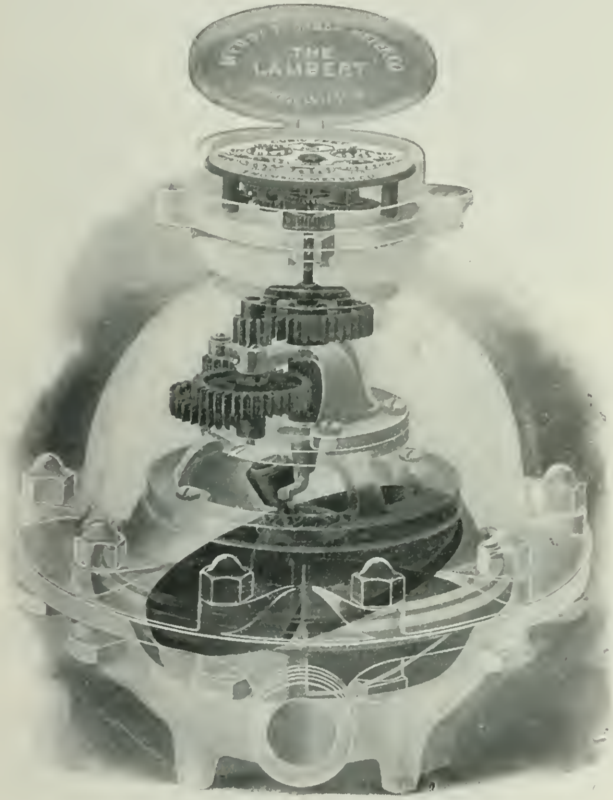
ARE THE REQUISITES OF A PERFECT WATER METER
THESE ARE THE PRINCIPAL FEATURES IN THE

“LAMBERT”



THE LAMBERT WATER METER

The unbreakable disc-piston, re-inforced with an internal steel plate, can be found only in the **Lambert Meter.** The growing popularity of the meter system is attributed by many to the inherent excellence of the **Lambert Meter.** It tells its own story in service.

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Venturi Meters
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Controlling Altitude Valves

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and Railroad Water Tubs

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for Water Mains

Other Water Work Specialties

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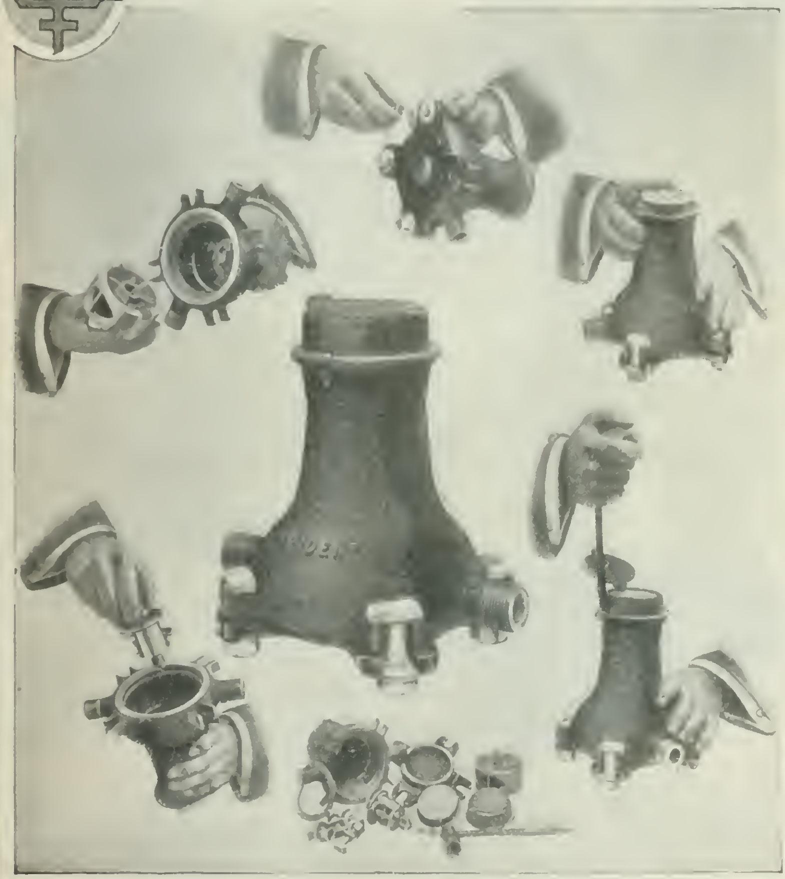
TRIDENT WATER METERS



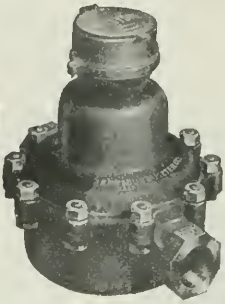
Assembling Simplicity of Trident Construction

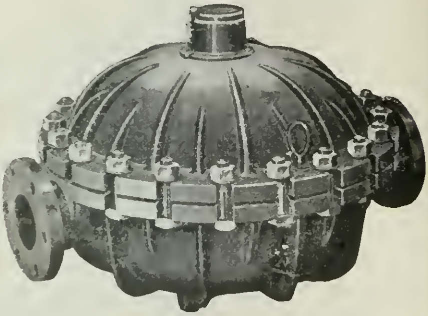
The above cut shows a Trident-Disk Meter dismantled and the extreme ease with which it can be assembled, by first putting in the gear train, then the disk-chamber, the frost bottom next, then the register and register box and the meter is complete. The Trident combination wrench is the only tool necessary to use.

NEPTUNE METER COMPANY

90 WEST STREET NEW YORK
CHICAGO, BOSTON, SANFRANCISCO,
ATLANTA, LOSANGELES, PORTLAND, SEATTLE

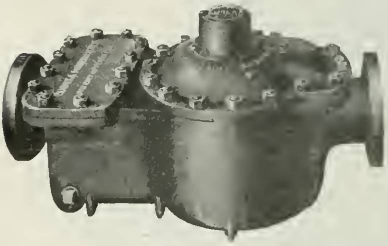
KEYSTONE
Water Meters





Designs of different sizes

The Keystone Water Meter is for house, factory and similar service. Sizes from $\frac{5}{8}$-inch to 2-inch inclusive have all bronze outer cases. Cases of 3, 4 and 6-inch sizes are of cast iron.



EUREKA
Water Meters

The Eureka Water Meter is designed for measuring large rapidly flowing bodies of water.

WRITE FOR CATALOG 117

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Main Office and Works, East Pittsburg, Pa.

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256 Madison St.

KANSAS CITY
6 West 10th St.

SEATTLE
8th and Madison Sts

SAN FRANCISCO, 149 New Montgomery St.

MAKERS OF GAS METERS AND WATER METERS

"Watch Dog Water Meters"

◆

GAMON METER COMPANY

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◆

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THAT THE ENGINEERS OF THE UNITED
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NIAGARA and AMERICAN
WATER METERS

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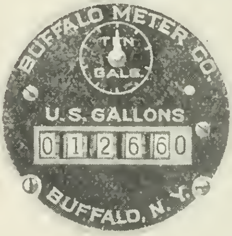
Fewest and Most Accessible Parts

ACCURATE
Jewel Bearing Intermediate Gears

DURABLE
Extra Thick, Strong Buoyant Disc



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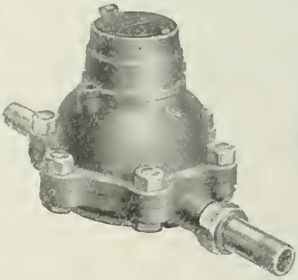
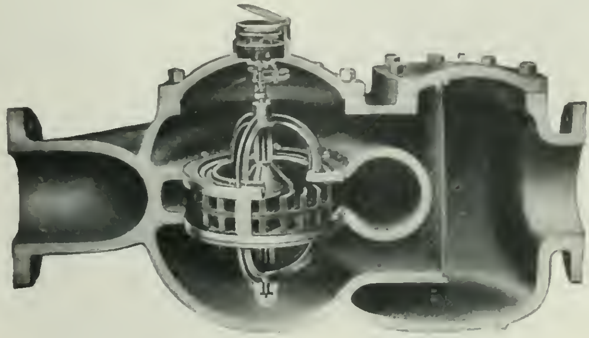


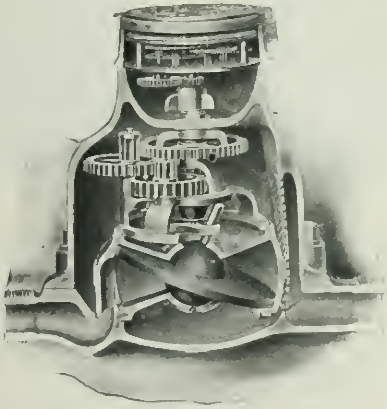
Standard Dial

BUFFALO METER COMPANY
290-296 TERRACE
Established 1892
BUFFALO, N. Y.

WORTHINGTON METERS
DISC PISTON TURBINE



SECTIONAL CUT FLAT DISC METER



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North American Building
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CHICAGO
770 Old Colony Building
CLEVELAND
New England Building
ATLANTA
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PITTSBURG
Oliver Building
KANSAS CITY
827 Scarritt Building
SEATTLE
524 First Avenue, South
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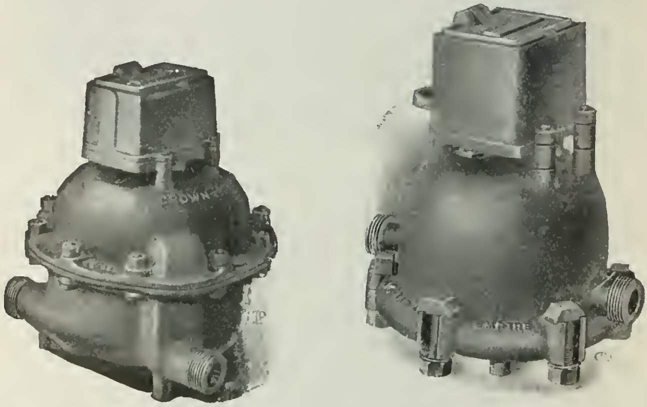
898 Ellicott Square
HYDRAULIC WORKS
Harrison, N. J.

Established 1840

LOWEST IN COST

CROWN, EMPIRE, NASH,
GEM, PREMIER



WATER METERS

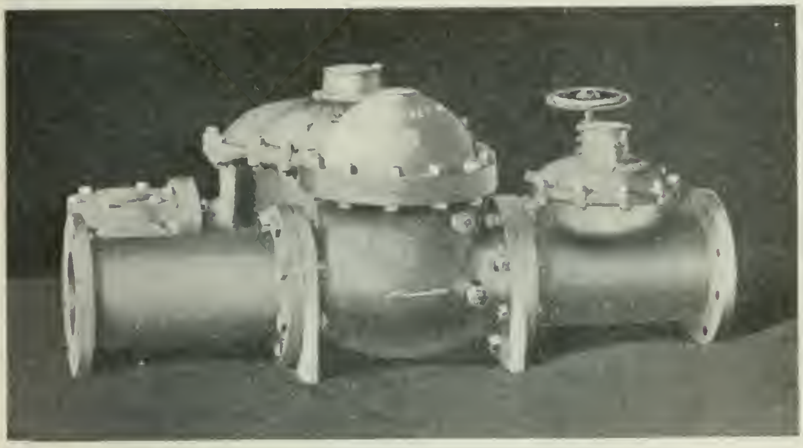
EXCEL IN EFFICIENCY
OUTLAST IN WEAR
ALL OTHER METERS

National Meter Company

JOHN C. KELLEY, President

84-86 CHAMBERS ST., NEW YORK

CHICAGO BOSTON PITTSBURG CINCINNATI LOS ANGELES



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USE THE HERSEY DETECTOR-METER
ON FIRE AND
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Endorsed by Water Departments and Underwriters

THIS IS THE ONLY METER

WHICH REGISTERS ALL LARGE FLOWS
WHICH REGISTERS ALL SMALL FLOWS
WHICH DOES NOT OBSTRUCT THE FLOW

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SULPHATE OF ALUMINA
For All Filters

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Originators of Mechanical Filtration

Announce they are the Sole Owners
of the well known

Jewell Patents

Covering the "Down Draft" or Negative Head

System of Mechanical
Filtration

Under these patents a consent decree was obtained against the Butler Water Company after extended litigation, and suit is now pending against the City of Harrisburg

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Norwood Engineering Co.
Roberts Filter Mfg. Co.
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Our Special 22% Alum

¶Especially efficient decolorizer of water carrying vegetable stains. ¶30% saving in freight. ¶We are sole manufacturers under patents. ¶We offer also all regular grades Filter Alum, Crystal Alum and Sulphate of Alumina. ¶Rust Inhibitive and Waterproof Paints for Engines, Boilers, Filters, Stand Pipes, Piping, etc.

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STANDARD FILTER ALUM

HIGHEST QUALITY
LOWEST PRICES

GENERAL CHEMICAL CO.
135 ADAMS STREET CHICAGO, ILLINOIS

CHLORIDE *of* LIME

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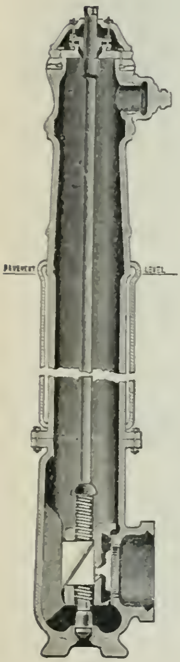

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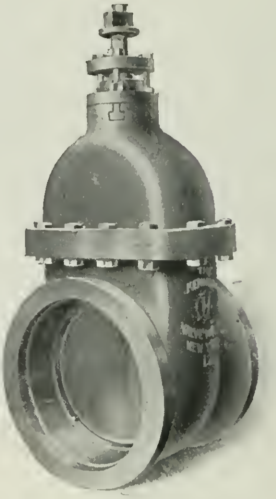

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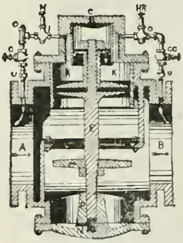

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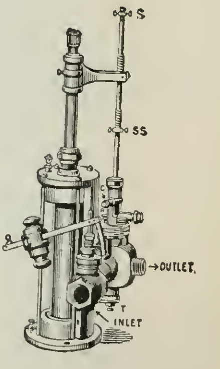

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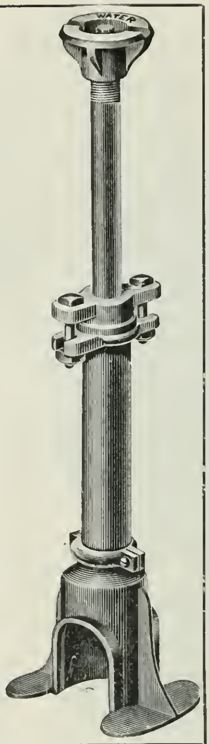

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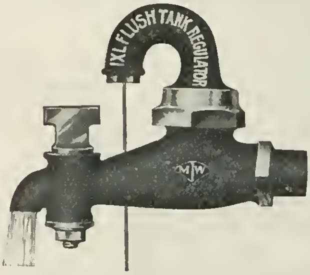

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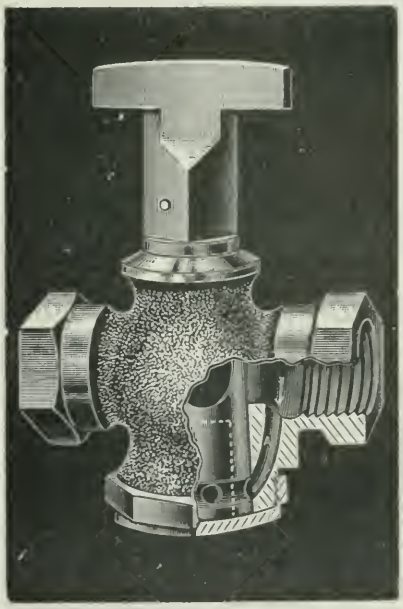

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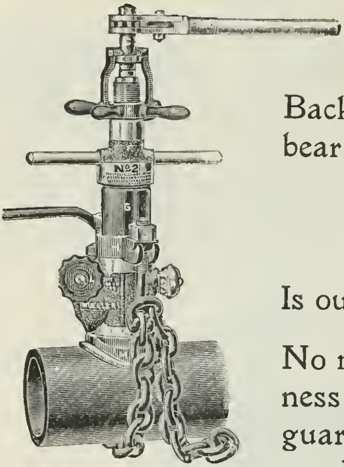

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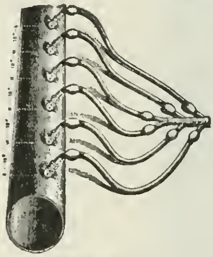

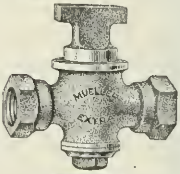

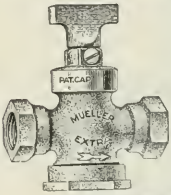

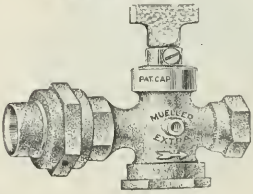

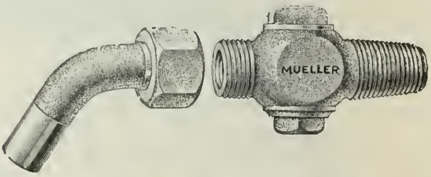

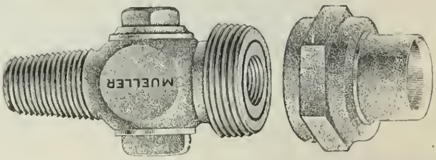

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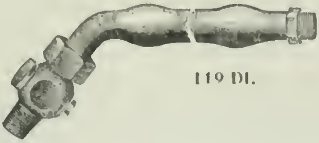
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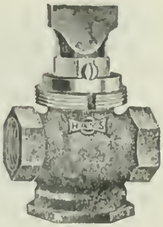
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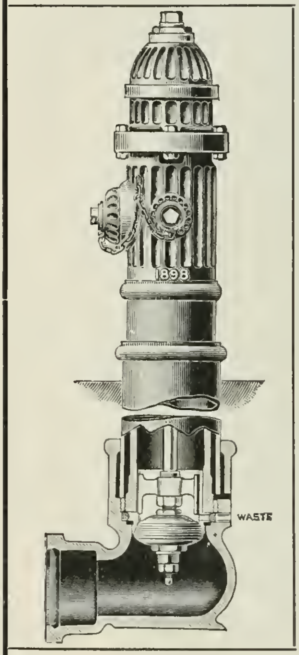

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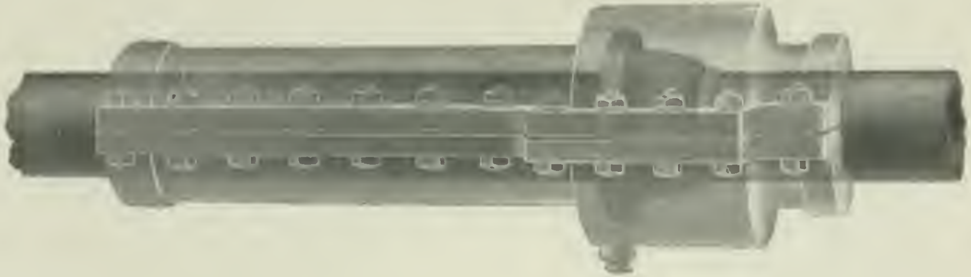

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